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ABSTRACT

This guide, when used in tandem with the videotape "Animals Without Backbones," helps students learn about invertebrates. These materials promote hands-on discovery and learning. The guide is composed of six curriculum-based teaching units: (1) "Getting Started"; (2) "Porifera"; (3) "Cnidarians"; (4) "Worms"; (5) "Mollusks"; (6) "Arthropods"; and (7) "Echinoderms." Each unit includes a list of printed resources and internet addresses to help students search for more information about invertebrates. There are four main features in this guide: teacher information, teacher-directed activities, student information, and student activities. Appendices include a list of science equipment suppliers, the videotape script, answers to student activities, and two videotape quizzes. (CCM)

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Animals Without Backbones:
The Invertebrate Story

by Brian Jerome, Ph.D., and Paul Fuqua

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ANIMALS WITHOUT BACKBONES:
THE INVERTEBRATE STORY

GRADE LEVEL 5-9

Brian A. Jerome Ph.D.
and
Paul Q. Fuqua

Illustrated by Peggy Zak Salvador

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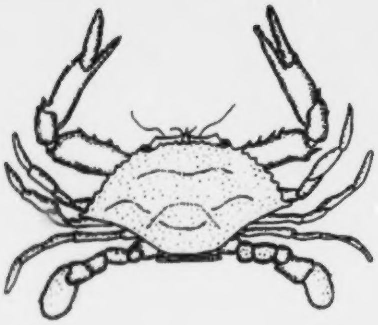
Table of Contents *Page*

Getting Started	**1**
Porifera	**5**
Cnidarians	**17**
Worms	**29**
Mollusks	**41**
Arthropods	**51**
Echinoderms	**65**
Appendix	**75**
Suppliers	**76**
Video Quizzes	**77**
Script for Video	**79**
Answers to Student Activities	**87**

Getting Started



Introduction:

Invertebrates are fascinating animals! They are extremely interesting and fun to study. We hope this guide will help turn on your students to these animals and make your classroom come alive with amazement and wonder. This guide, when used in tandem with the United Learning video *Animals Without Backbones*, is an invaluable combination in helping your students learn about invertebrates. Both are designed to help you promote hands-on, discovery and learning. The ideas and methods covered utilize cutting edge technologies and up-to-date information. Each unit has a list of curriculum-based internet addresses and creative assessment alternatives.

This Unit of Study Includes:

The complete Unit of Study, *Animals Without Backbones: The Invertebrate Story* consist of:

- **A two-part video** presentation (Running time: Part 1 - 22:30 with quiz; Part 2 - 13:25 with quiz)
- This curriculum/standards-based **Teacher's Guide**
- **Blackline Reproduction Masters**. Packaged separately in an accompanying envelope, these masters may be copied an unlimited number of times by the original purchaser of this Unit of Study.

You can order additional copies of this *Guide* by calling United Learning toll-free at 1-800-424-0362.

What the Video Covers:

Part one of the video examines the simpler invertebrates, beginning with an explanation of the term "invertebrate." The video then moves on to each major invertebrate group through the mollusks. Part one ends with a short, optional *Video Quiz*.

Part two of the video deals with the more complex echinoderms and arthropods. It is also followed by a short *Video Quiz*.

Student Quiz Sheets and *Answers* for both *Video Quizzes* are provided in the *Appendices* section of this *Guide*. Blackline reproduction masters of both *Quizzes* are provided in an accompanying envelope. You can use these to make copies for your students.

Your On-Line Connection

Surfing the net is a part of many of today's active teaching strategies. This Guide lists a number of web page addresses. These pages are a great resource that can provide you and your students with a wealth of up-to-date and interesting information about different invertebrates. You can even contact Dr. Brian Jerome at *drbjerome@aol.com*.

Meet Dr. Brian Jerome

An experienced science teacher, Dr. Jerome traveled widely in search of the different invertebrates shown in *Animals Without Backbones*. He has taught science to children in grades 3 - 10 focusing on inquiry-based, hands-on activities. Dr. Jerome has a Ph.D. in Education from Syracuse University and a B.S. in Science Education from the University of Vermont. He has led science workshops for over 3,000 teachers throughout the nation for the JASON Project, an interactive distance-learning program. He has coordinated the JASON Project broadcast to over 50,000 students at the National Geographic Society. His organization, Jerome Education Associates, specializes in curriculum development, teacher training, and science education.

About This Teacher's Guide

This *Teacher's Guide* provides an overview of the major invertebrate phyla. It is fully linked to key middle school curricula concepts and can be used either on its own or with any standard middle school life science text.

The *Guide* is composed of six curriculum-based *Teaching Units*. Each deals with one or more important invertebrate phyla.

In addition, each *Unit* contains helpful corollary material. This includes a list of printed resources and internet addresses to help your students "surf the web" in search of information about the invertebrates.

Features of this Guide

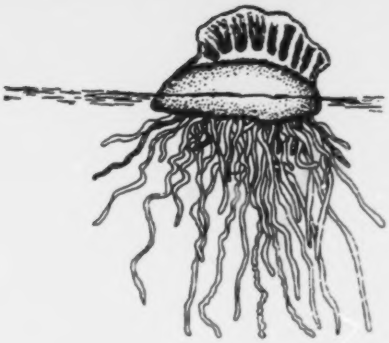
There are four main features in this guide: Teacher Information, Teacher-Directed Activities, Student Information and Student Activities. Each of these will be discussed briefly below to help you become familiar and comfortable with the layout of the curriculum.

A. Teacher Information: Unit Overview

The beginning of each unit has several pages of information for you, the teacher. The first two pages consist of the *Unit Overview* and have the following sections:

1. **Suggested Pacing Chart:** This provides one among many possibilities for teaching the information and activities in the unit. This is just a suggested approach, so feel free to teach the material in the order and style that you think best meets the learning style of your students.
2. **Links to National Science Standards:** This contains just a few of the National Science Education Standards which are met in the unit. All are taken directly from the National Research Council book, *National Science Education Standards, for Grades 5 - 8.*
3. **Interdisciplinary Connections:** Suggestions are provided for ways that an invertebrate phylum can be taught across the disciplines or in an interdisciplinary manner. Interdisciplinary suggestions are provided for Language Arts, Mathematics, and Social Studies.

Features of this Guide (cont.)



4. **Surfing the Web:** Annotated internet addresses are provided that directly relate to the animals studied in the unit. Many of these websites can be easily modified to make exciting lessons and provide great current information.
5. **Assessment:** Suggestions are provided for assessment techniques.
6. **Resources:** A bibliography is provided of written and multi-media materials pertaining to the animals addressed in the unit.
7. **Lecture Notes:** A one-page lecture outline is provided which covers the main topics relating to a specific group of animals. The concepts covered are for middle school students.

B. Teacher-Directed Activities

Each unit contains one or more Teacher-Directed Activities that are titled *Investigations*. These are hands-on, action-oriented experiments. The teacher has control over the pacing and depth of the investigation. It is suggested that students experience some degree of working independently. Most of the materials can be easily obtained at a grocery store or through a science supplier. Suggestions for assessment are also provided.

C. Student Information

Student information consists of content material with which students should become familiar. This is material that is commonly covered in conventional textbooks. Student Information pages should either be photocopied for each student or made into overhead transparencies so that the entire class can read them together. *Blackline Reproduction Masters* for each student information sheet are provided in the accompanying envelope.

Two Types of Student Information Sheets:

1. ***Those Amazing .... (phylum)!*** These cover basic information for each phylum. At the end of the reading is a list of vocabulary words that students should define.
2. ***Cultural Connections.*** You can make up questions for students based on the reading or have a class discussion about it.

D. Student Activities

Pages titled Student Activities are designed for students to write on; therefore, it is suggested that you photocopy these pages for each student. These pages consist of diagrams, data tables and discovery exercises. Each activity should be introduced by the teacher, and then students should work either independently or cooperatively in groups. *Blackline Reproduction Masters* for each student activity are provided in the accompanying envelope.

A Word About Safety

Science is a hands-on activity. Students love science when it involves using their senses and working together to find a solution to a problem. But in order to create this type of experience in a classroom, certain strict guidelines should be established, not only for behavior, but for safety as well.

Post your classroom rules where everyone can see them clearly. The activities and investigations in this guide do not involve dangerous chemicals, flames or apparatus. However, before every lesson students should be instructed about potential hazards.

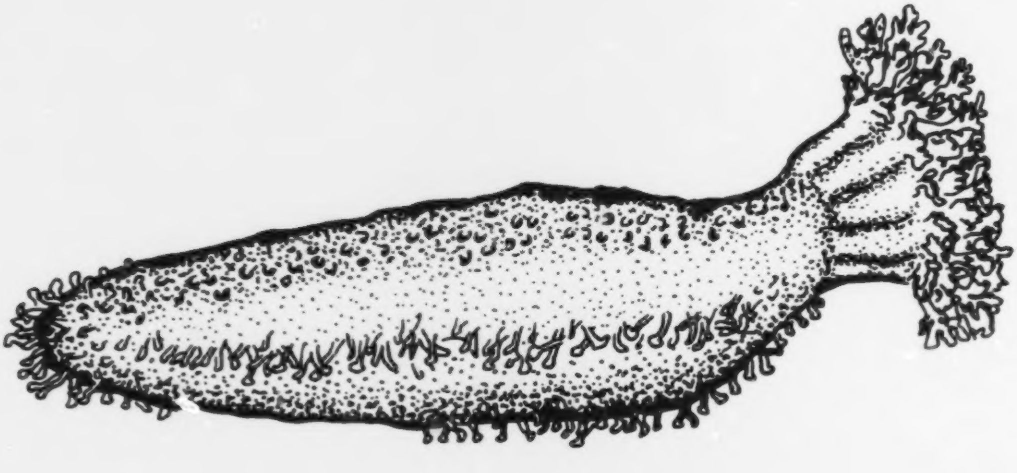
Have Fun!

This guide will help your classroom be a more exciting and fun place for both you and your students. It has been designed to be as teacher-friendly as possible, written clearly, illustrated cheerfully, and created with both students and teachers in mind. Good luck, and have lots of fun exploring the exciting world of invertebrates!

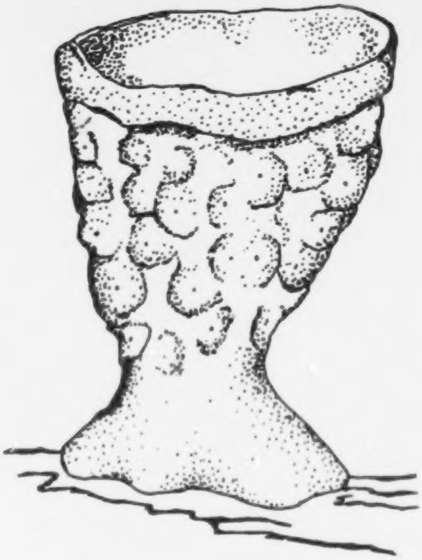
Finally, We Want To Hear From You

We value your comments, and we are glad to try and answer your questions. You can reach United Learning at 1-800-424-0362 or visit their website at *http://www.unitedlearning.com*. Or you can direct questions about this Guide by sending e-mail to Dr. Brian Jerome at *drbjerome.aol.com*.

And don't forget to visit the United Learning home page on the World Wide Web at *http://www.unitedlearning.com*. It is continually updated and will keep you posted on their complete library of productions and other helpful information.



Basket sponges, such as the one on the right, can grow a foot or more high. They can filter hundreds of gallons of water a week.



THE
PORIFERA

This Unit Includes

I. For the Teacher:

- **Teacher Information**
  - *Unit Overview*
  - *Lecture Notes*
- **Teacher-Directed Activity**
  - *Investigation: What Are All Those Holes For?*
  - *Investigation: Super Strong Spicules*

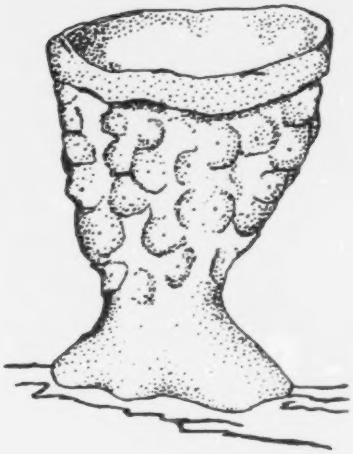
II. For the Student:

- **Student Information**
  - *Cultural Connections: Sponge Divers*
  - *Those Amazing Porifera!*
- **Student Activity**
  - *Name That Sponge*
  - *What is a Porifera?*

Unit Overview

Organism Highlights:

The phylum Porifera is the simplest group of invertebrates that students will explore. These animals are often collectively referred to as the sponges. Students will learn why these organisms are animals, even though they often look like plants. The activities and investigations are designed to familiarize students with the major features of the phylum, and serve as a great introduction to invertebrates.



Suggested Pacing Chart:

Day 1:

1. Show the United Learning Video: *Animals Without Backbones.*
2. Students should read Student Information Sheet, *Those Amazing Porifera!* on page 13, or the Blackline Master, and define the terms at the end of the reading.
3. For homework, students should read the Student Information Sheet, *Cultural Connections: Sponge Divers,* on page 12 or the Blackline Master.

Day 2:

1. Give a brief lesson/lecture on Porifera. Lecture notes are provided on page 8 if you choose to use them.
2. For homework, students should complete Student Activity Sheet, *NameThat Sponge,* on page 14 or the Blackline Master.

Day 3:

1. Conduct Teacher-Directed Activity, *Investigation: What Are All Those Holes For?* on page 9.
2. For homework, students should write up the lab report.

Day 4:

1. Conduct Teacher-Directed Activity, *Investigation: Super Strong Spicules,* page 10. **Remind students to be careful when puncturing holes in containers with a nail.**
2. For homework, students should complete the Student Activity, *What is a Porifera?*on page 15 or the Blackline Master.

Links to National Science Education Standards:

1. Science as Inquiry

"With practice, students should become competent following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations." Communicate Scientific Procedures and Observations, Grade 5-8

2. Life Science

"All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment." Regulation and Behavior, Grade 5-8

3. Life Science

"Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive." Regulation and Behavior, Grade 5-8

Interdisciplinary Connections:

Language Arts

We use metaphors based on natural phenomena and animals. For example, we often say, "She is like a sponge," meaning that a person remembers a lot of what she experiences. We refer to something as being "spongy," meaning it feels like a sponge. As a class, try to think of as many phrases based on sponges as you can. You might also want to try to think of phrases based on other animals, such as squirrels or birds.

Mathematics

Based on observing sponge spicules, various measurements can be taken. The length, shape, and diameter can be calculated with a ruler or via the field dimensions of a microscope. These measurements in turn can be arranged in such a way to create meaningful data that can be graphed. It is also possible to measure the angles which spicules create. This might be a good opportunity to practice using a protractor.

Social Studies

The history of sponges can be researched. Sponges have been used for thousands of years. The Greeks and Romans used sponges gathered in the Mediterranean. Students can also investigate the numerous uses of sponges today and throughout history. Sponges are not just used for cleaning.

Surfing the Web:

1.) http://www.ucmp.berkeley.edu/porifera/poriferasy.html

This website includes beautiful porifera pictures with descriptive information on the ecology and morphology of sponges. It also includes close-up images of sponge spicules.

2.) http://www2.tcd.ie/People/Bernard.Picton/porifera

This website in Ireland provides basic sponge information and links to other sites, such as Who's Who in Studies of Porifera, and a Species Directory to Sponges.

3.) http://mmm.mbhs.edu/marine/marine_org/invertebrates/SpongeCniderian.html

A website that has interesting facts and explanations of the differences between porifera and cnidaria.

Assessment:

Students produce numerous portfolio assessment pieces in this unit, such as student activities, two investigations which produce porifera models and simulations, vocabulary lists, comparative grid, and diagrams. Students can display these items in the classroom, put them on bulletin boards, or 3-hole punch them and place them in their notebooks. Furthermore, students can write a research paper on a specific group of porifera species which can also be used to assess student understanding.

Resources:

Anderson, Robert. *All About Sponges: Fascinating Animals of the Sea*. ZOE Enterprises, 1984.

Gosner, Kenneth. *A Field Guide to the Atlantic Seashore*. Houghton-Mifflin, Boston, 1978.

Kricher, John, and Gordon Morrison. *Peterson Field Guide Coloring Books: Seashores*. Houghton-Mifflin, 1989.

Video - *Animals Without Backbones: The Invertebrate Story*. United Learning. Niles, IL. 1-800-424-0362.

Lecture Notes

I. Background

- A. Porifera means animal with pores, and sponges have lots of pores.
- B. Sponges are very simple animals that have been on earth a very long time.
- C. There are over 5,000 different species
    - 1. Most live in salt water, with a few (150 species) in fresh water.
- D. Been used for thousands of years for cleaning and other purposes.
- E. Natural sponges are better than synthetic sponges:
    - 1. Hold more water without dripping.
    - 2. Easier to clean.
    - 3. Last longer.

II. Body Plan/Structure

- A. Sponges are the most primitive multicellular animal group.
- B. Do not have organs, muscles, nerves, mouth or digestive cavity.
- C. Have specialized cells for different functions.
- D. Porous body with two types of openings:
    - 1. Water flows into sponge through many *ostia.*
    - 2. Water flows out through one or more *oscula.*
- E. Skeleton
    - 1. Skeletons of some sponges are made up of small, hard *spicules.*
        - a. Spicules come in many different shapes and sizes.
        - b. Made of *calcium carbonate* or *silica.*
    - 2. Spicules are woven together by material called *spongin.*

III. Food Getting

- A. *Filter feeders* - eat primarily plankton.
- B. Special cells called *collar cells* have a *flagellum.*
    - 1. Cause currents of water to flow through sponge.
    - 2. Cause food and oxygen to enter and waste to leave.
- C. A four inch tall sponge that is 1/2" in diameter can filter up to 30 gallons of water a day!

IV. Reproduction - two modes

- A. Asexual
    - 1. Budding - new sponge is grown on parent and falls off to create new animal.
    - 2. Sponges can regenerate after being pulled apart.
- B. Sexual
    - 1. Eggs and sperm released into the water.
    - 2. Most species are *hermaphroditic* - one individual possesses both eggs and sperm.
    - 3. Eggs and sperm are released at different times to assure cross fertilization.

Investigation: What Are All Those Holes For?

Objective:

Students will explore the relationship between porosity and water flow in a simulated sponge they create.

Materials:

- Plastic soda bottles or aluminum soda cans
- Small nails
- Stop watch or watch with seconds hand

Background:

Porifera are named for the abundant pores for which they are so characteristic. Natural sponges contain hundreds, if not thousands, of small holes or pores. The purpose of the pores is quite ingenious and plays a critical role in food-getting. As porifera are sessile organisms, they cannot move about to capture their food. Therefore, they must bring their food to them.

Most sponges are designed so that plankton-ridden water enters pores via currents created by small, beating flagella. Once inside, cells capture the plankton and digest it. Water exits out of the top of the sponge. A sponge's existence depends on circulating large volumes of water through its body to obtain food. It is not uncommon for snorkelers to feel the surge of water from a sponge as they swim over it.

Procedure:

1. Explain to students the information conveyed in the preceding Background statement.

2. Ask students how the body of a sponge is uniquely designed to filter water and capture plankton. Show them a diagram of a sponge and discuss its structure.

3. Ask students how a sponge's body plan could be modified to regulate the amount of water it processes. Write the students' ideas on the board.

4. To test their ideas, students will create a simulated sponge with a bottle or can. Have students punch three or four holes in the container. **Instruct students to use extreme caution.**

5. Students should create data tables with one column to record the number of holes in the container, and an adjacent column for the time in seconds for the water to exit the container.

6. Dip the container in a tub/sink/bucket full of water until the bottle or can is full. Lift the container out of the water. Students should record the time it takes for water to exit the container.

7. Repeat the procedure several times, each time adding a few more holes, and recording the amount of time it takes the water to exit the can.

8. Ask students why it is advantageous for sponges to have lots of pores.

Assessment:

Students can graph their data from their data tables. In a short paragraph, they should explain what the data means. In turn, they should also explain how these principles relate to sponges.

Conclusion:

Explain to students that a real sponge functions slightly differently than the simulated sponge in that the water flows in a reverse manner. It flows from outside the sponge inward through the sides and out the top. Discuss the advantages and disadvantages of being a filter-feeder.

Investigation: Super Strong Spicules

Objective:

The unique ability of sponges to support themselves via spicules will be investigated by students when they actually see spicules under the microscope and create sponge replicas.

Materials:

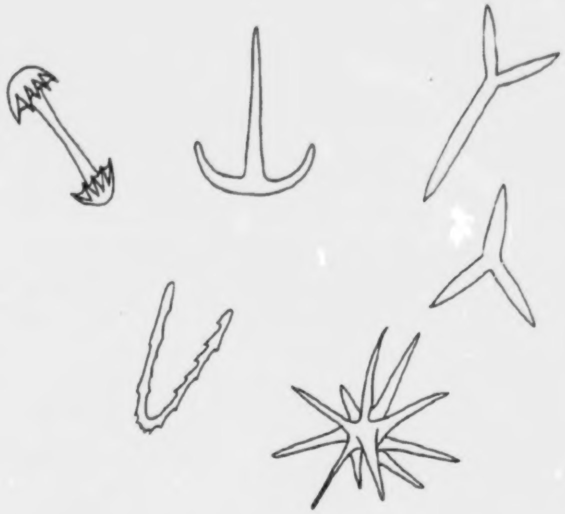
- Pipe cleaners or paper clips or stiff wire
- Strips of newspaper
- Papier-mache paste

Optional:

- Sponge spicules (order through scientific supply company)
- Microscope
- Natural sponge

Background:

Although sponges are soft, squishy, and lack skeletons, they stand amazingly erect in the water. How do these animals seemingly defy gravity in the absence of these features? The answer lies in a small, uniquely shaped piece of silica or calcium carbonate called a spicule. As seen under a microscope, spicules have a wide variety of shapes. In fact, different species of sponges can even be identified by their spicules. When woven together with a tissue called spongin, the spicule-spongin matrix provides an amazingly resilient material.



Spicules come in many different shapes and sizes.

Procedure:

1. Pose students with the problem which sponges face in supporting themselves without the aid of a skeleton. Ask students if they have any idea how sponges do this.

2. Explain the information about spicules and spongin described in the Background section.

3. Students will make a sponge exterior demonstrating the supportive properties of spicules and spongin. Students will first make spicules from pipe cleaners, paper clips, or stiff wire. The spicule drawings above should serve as the basis for their design. They can use the shapes above or make shapes of their own. The spicules should be about 5 cm. in diameter.

4. After creating 15-20 spicules, students will connect them via papier-mache. A plastic 2 liter soda bottle will serve as the mold. First wrap the bottle with construction paper and tape it along the seam.

5. Next tape the spicules to the construction paper.

6. Begin placing papier-mache strips over the spicules until the entire bottle is covered, including the bottom. Let the papier-mache harden.

7. After the papier-mache has hardened, students should remove the plastic bottle. Carefully cut away the construction paper.

8. Carefully place a layer of papier-mache on the inside of the sponge and let it harden.

9. With great caution, puncture holes in the sides of the sponge with a nail to represent the ostia. **Be very careful when puncturing holes in the container. It might be best if the teacher did this for students.**

10. Feel free to paint your sponges and even glue bits of yarn to the inside to simulate the flagellum on collar cells.

Fun Facts:

Sponges range in size from 1 centimeter to over 2 meters (over 6 feet) in height.

When you are washing with the natural sponge, you are using a skeleton of a once living animal!

Optional:

1. Order sponge spicules from a Scientific Company (see Appendix). They are relatively inexpensive and are well worth the money. In small groups, have students look at the spicules through the compound or dissecting microscope.

2. Students should look at several spicules and draw their observations.

3. Have students draw the spicules on the blackboard until all the shapes viewed by the class are represented.

4. If time permits, provide a natural sponge for students to observe. Ask students to describe differences between a synthetic sponge and a natural sponge. They should describe differences in color, texture, sponginess, ability to hold water, and ease of use in cleaning.

Assessment:

Students can verbally or in writing explain the different parts of their models. They should use the following terms in their explanations: ostia, osculum, spicules, collar cells,and flagellum.

Conclusion:

Students can compare their sponges with each other. Explain that variations among sponges in the class are also represented by great variation in nature. Discuss how water flows in and out of the sponge. Ask students the role that spicules play in supporting the sponge. Discuss how engineers have learned a lesson from sponges by reinforcing concrete with pieces of metal called reinforcement bars.

There are thousands of different sponges. Most live in salt water, but some live in fresh water.

Cultural Connections: Sponge Divers

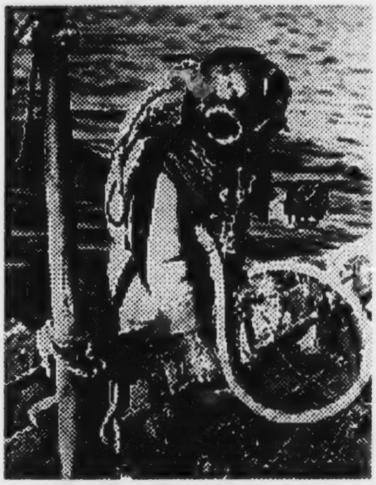
There are millions of sponges that are used every year for many different purposes. They are used for all kinds of things, from washing cars, to applying make-up, to painting walls. While most of the sponges you use at home are made in factories, some of them may be natural. Natural sponges grow in nature, in lakes or the ocean. You most commonly see natural sponges used for bathing.

Natural sponges tend to last longer than synthetic sponges. They have tough elastic fibers that endure much better than the rubbery synthetic sponges.

While there are thousands of different kinds of natural sponges in the world, only six are soft enough to be considered marketable. The Mediterranean sponges are the softest and best; those of the Red Sea are next in quality; and the West Indian species are coarser and less durable. In the United States, commercial sponges may come from Florida.

People have collected natural sponges for thousands of years. Some of the earliest accounts of sponge harvesting come from the Mediterranean by the Greeks.

Today sponges are gathered by divers, usually working from small boats. Many divers use only snorkeling gear and gather as many sponges as they can in a single breath. Another method of gathering sponges in shallow water is by hooking them with a stick. One person rows a boat, while the other person looks for sponges through a glass-bottomed bucket. The sponge is pulled up with a two-pronged hook on the end of a long stick. When sponges are removed from the ocean, they are usually covered with a tough, dark, leathery skin. The sponges are washed and allowed to dry in the hot sun. The living tissue is allowed to decompose. The remaining undecomposed skeleton of spongin fibers is then washed and pounded with a mallet to break up other invertebrates living inside the sponge.



Sponge divers formed a thriving community in Tarpon Springs, Florida in the early 1900's.

Sometimes the sponges are bleached and dyed different colors. They are often cut into smaller pieces. Because most sponges harvested for sale do not have spicules, they are softer and more flexible. This property allows sponges to soak up water, and allows water to be squeezed out of them.

In Tarpon Springs, Florida, growing sponges on sponge farms is a big business. For nearly 100 years people in Tarpon Springs have harvested sponges. If you would like to learn more about the sponge business, search the World Wide Web. One site you might want to visit is located in Tarpon Springs, Florida at: *http://www.spongefishing.com*

Those Amazing Porifera!

The brightly colored sponges you use to wipe up the kitchen counter are not natural sponges, but are made in factories. Natural sponges can be very colorful when living in water, but when sold in stores, they are a brownish color. In nature, they range in color from purple to brown to blue.

"Porifera" comes from the word pores. Sponges, which are the only animal in this phylum, are filled with pores or small holes. Sponges are among the simplest of the invertebrates. They have no tissues or organs.

There are several thousand species, with most living in salt water, but some also live in fresh water. They are most common in warm tropical waters and are found throughout the world. In the United States, they are commonly found along the coast of southern Florida.

The body plan of most sponges is quite simple. They have an outer layer of cells called an ectoderm, and an inner layer of cells called an endoderm. Between the two layers of sponge are small, hard pieces of calcium carbonate, or silica, called spicules. Spicules come in a wide variety of shapes and sizes. A flexible, soft protein called spongin weaves spicules together. They help support the sponge.

On the inside of the sponge are special cells called collar cells that have little beating hairs called flagella. They cause water to move through the sponge. Sponges feed by moving water into lateral incoming pores called ostia. Water leaves the sponge through one or more holes called oscula.

They eat small plants and animals that float in the water. As these things pass through the body of the sponge, cells capture them. Since sponges eat things as water filters through their bodies, they are called filter-feeders.

Reproduction can occur either sexually or asexually. In sexual reproduction, eggs and sperm unite to produce a free-swimming larva. Reproduction can also occur asexually when small sponges develop from a parent sponge. These small sponges, called buds, eventually break off to form a completely new organism.

Sponges are sessile, meaning they do not move. When a sponge becomes an adult, it attaches itself to an object in the water or on the bottom. Sponges do not move from spot to spot. Because they do not move, many people mistake sponges for plants. While they may look like plants, they are not because they capture their own food and do not make it from sun.

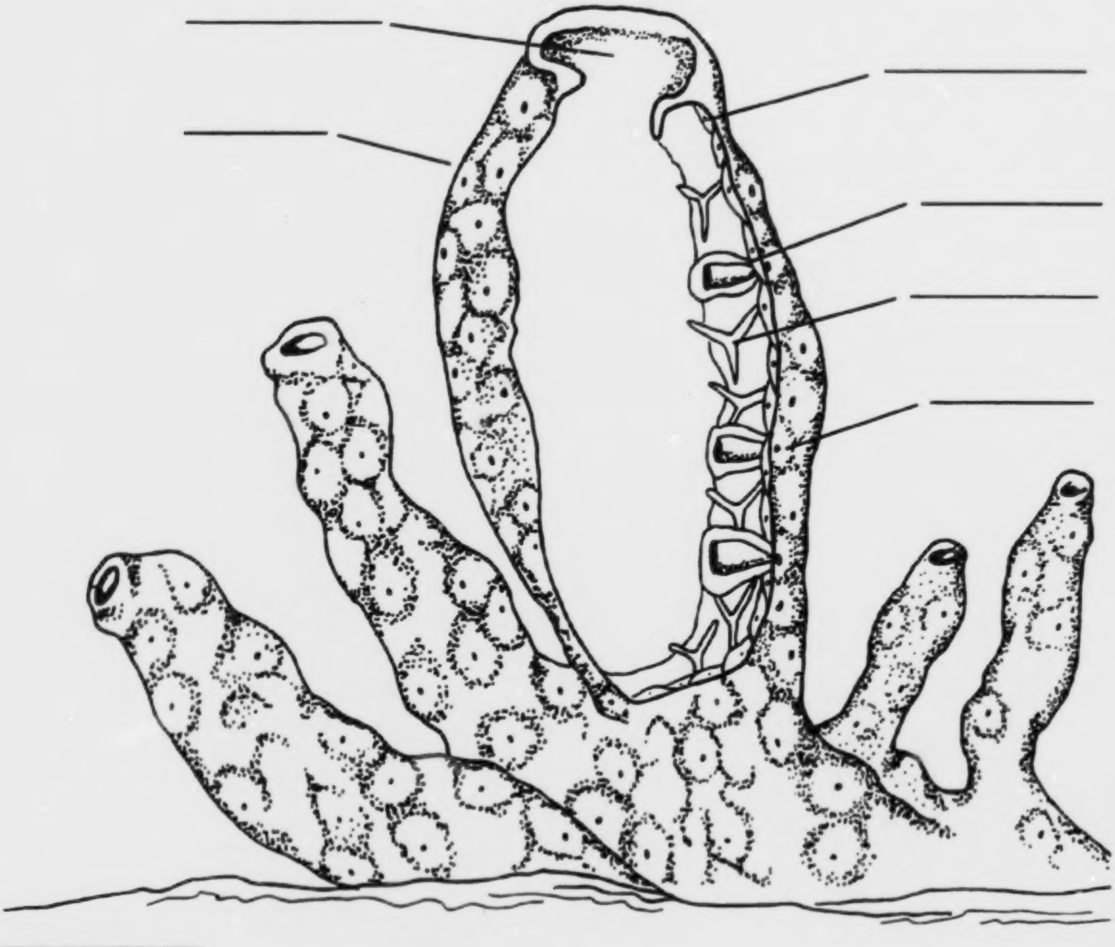
Next time you wash with a natural sponge, think of it not as a sponge, but as a wild animal that once lived in the ocean!

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

Sessile
Endoderm
Spicule
Ectoderm
Spongin
Buds
Flagellum
Filter-feeder

Name That Sponge

Using a biology book, a textbook or an encyclopedia, fill in the correct parts of this sponge. Color the endoderm and ectoderm different colors. Also color the collar cells and spicules differently.



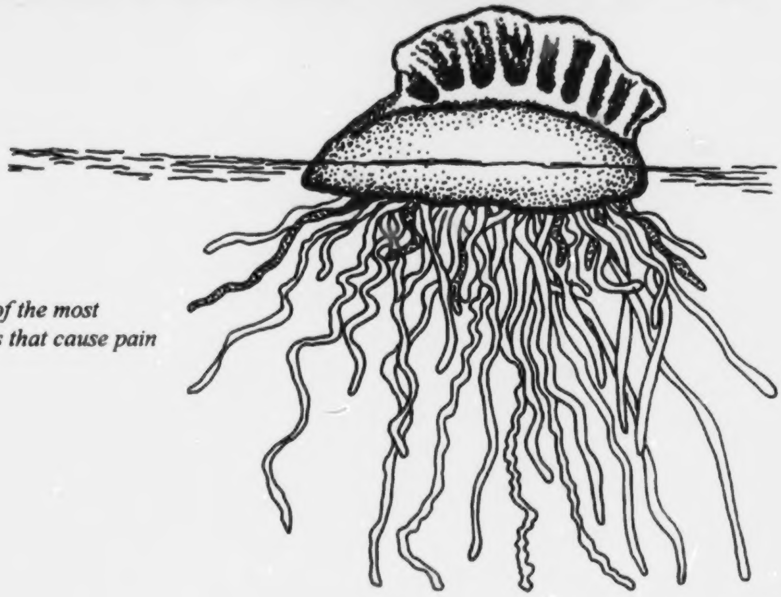
Provide the definition, state the function, and then place the term on the correct line on the diagram:

- Ostia
- Collar Cell
- Spicule
- Endoderm
- Osculum
- Ectoderm

What is a Porifera?

Directions: Use textbooks, encyclopedias, and other science books to fill in the specific characteristics of Porifera.

Characteristic	Porifera Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	



The Portugese Man-of-War is one of the most feared jellyfish. It can inflict stings that cause pain for days.

THE CNIDARIANS

This Unit Includes

I. For the Teacher:

- **Teacher-Information**
  - *Unit Overview*
  - *Lecture Notes*
- **Teacher-Directed Activity**
  - *Investigation: Life as a Jellyfish*

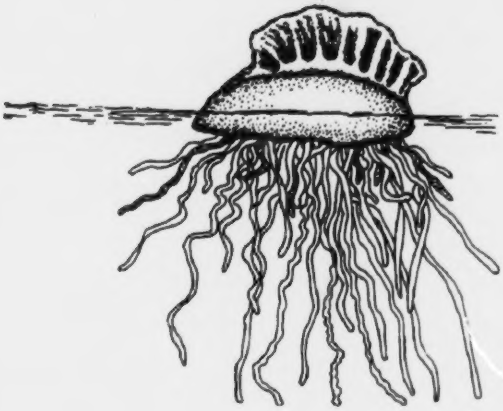
II. For the Student:

- **Student Information**
  - *Cultural Connections: Belize - A Trip to Paradise*
  - *Those Amazing Cnidarians!*
- **Student Activity**
  - *Name that Cnidarian*
  - *Growing Up is Tough!*
  - *What is a Cnidarian?*

Unit Overview

Organism Highlights

The cnidarians (formerly called coelenterates) are a fascinating group of animals which includes jellyfish, sea anemones, hydras and corals. Your students will find these animals to be interesting and fun due to their unusual shapes, life cycles, and paralyzing stings. The unit is designed to familiarize students with the major features of the phylum.



Jellyfish use stinging cells on their tentacles to capture their prey.

Suggested Pacing Chart:

Day 1:

1. Give a brief lesson/lecture on the Cnidarians. Lecture notes are provided on page 20 if you choose to use them.
2. Students should read the Student Information Sheet, *Those Amazing Cnidarians!*, on page 24 or the Blackline Master.
3. For homework, students should do Student Activity, *Growing Up is Tough!*, on page 26 or the Blackline Master.

Day 2:

1. Students should complete the Student Activity, *What is a Cnidarian?*, on page 27 or the Blackline Master.
2. Students can also make representative drawings of various cnidaria, such as hydra, jellyfish, and coral.

Day 3:

1. Conduct the hands-on Teacher-Directed Activity, *Investigation: Life as a Jellyfish*, on pages 21-22. **Remember to be careful when heating and pouring jello - wear eyeglasses! Students should not heat and pour jello.**

Day 4 :

1. Have students conduct Student Activity, *Name that Cnidarian* on page 25 or the Blackline Master.
2. View living hydra under a dissecting microscope (Optional).
3. Students should read the Student Information Sheet, *Cultural Connections: Belize-A Trip to Paradise*, on page 23 or the Blackline Master.

Links to National Science Education Standards:

1. Life Science

"Living systems at all levels of organization demonstrate the complementary nature of structure and function." Structure and Function in Living Systems, Grade 5-8

2. History and Nature of Science

"It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by others." Nature of Science, Grade 5-8

3. Life Science

"Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive." Regulation and Behavior, Grade 5-8

Interdisciplinary Connections:

Language Arts

Have students imagine that they are the first people in the world to see a coral reef. How would they describe it to the world? Write a short half page article for the newspaper.

Mathematics

Have students estimate how many coral polyps live on the Great Barrier Reef. There can be as many as 10 coral animals in a square inch. How many animals would be on a square mile of a reef? Using an atlas to estimate the number of square miles on the Great Barrier Reef of Australia, compute the number of coral polyps in this area.

Social Studies

After reading *Cultural Connections: Belize-A Trip to Paradise*, page 23, your class can describe how ecotourism can help preserve the coral reefs of Belize. Have students prepare short research papers about ecotourism. They should include a section about their own imaginary ecotourism company. The can also make their own travel brochure for their companies describing the ecotourism experience in Belize or another place like the Florida Keys. Where would you go and how would you help to maintain these natural areas?

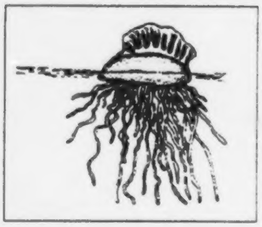
Surfing the Web:

1. http://www.demon.co.uk/coralcay

The Coral Cay Conservation website describes the activities of one of the most active coral reef research and conservation organizations. It provides in-depth information about coral reefs in exotic places like Indonesia and Belize.

2. http://www.bev.net/education/SeaWorld

Sponsored by SeaWorld, this website describes Corals and Coral Reefs.



Assessment:

Students produce numerous portfolio assessment pieces in this unit, such as student activities, investigations, vocabulary lists, comparative grid, diagrams, and a short jellyfish story. Students can 3-hole punch these items and place them in their notebooks. Furthermore, students can write one-page reports summarizing the major features of cnidarians. Research papers on a specific group or cnidarian species can also be used to assess student understanding.

Resources:

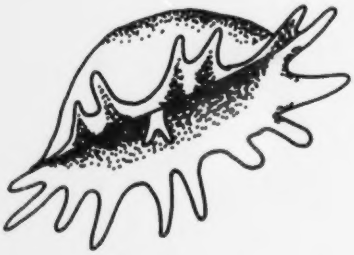
Gosner, Kenneth. *A Field Guide to the Atlantic Seashore*. Houghton-Mifflin, Boston, 1978.

Gray, William. *Coral Reefs & Islands: The Natural History of a Threatened Paradise*. David & Charles, Devon, United Kingdom, 1993.

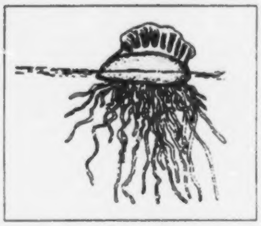
Kricher, John, and Gordon Morrison. *Peterson Field Guide Coloring Books: Seashores*. Houghton-Mifflin, 1989.

Video - *Animals Without Backbones: The Invertebrate Story*. United Learning. Niles, IL. 1-800-424-0362.

Video - *The Kingdom of Animals*. United Learning. Niles, IL. 1-800-424-0362.



The Ephyra is the multi-armed stage of a juvenile jellyfish.



Lecture Notes

I. Introduction

- A. Wide variety of invertebrate animals with dazzling colors and shapes.
  - 1. Animals include corals, jellyfishes, hydras, and sea anemones.
- B. Two basic body shapes.
  - 1. Vase shaped polyp.
    - a. Remains in one place.
  - 2. Bowl shaped medusa.
    - b. Weak swimmers that drift with currents.

II. Body Plan and Function

- A. Hollow central cavity with one opening called the mouth.
  - 1. Have nematocysts - special stinging structures.
    - a. Used to stun or kill its prey.
    - b. Found on tentacles - surround its mouth.
- B. Pulls its prey into its mouth with the tentacles.
- C. After digestion, releases waste through its mouth.
- D. Contains groups of cells that perform special functions.
  - 1. Nerve net-a simple nervous system concentrated around its mouth, spread through body.
- E. Have tissue but no organs.
- F. Bodies have radial symmetry.
- G. Reproduce both sexually and asexually.
  - 1. Asexually by budding.
  - 2. Sexually by producing eggs and sperm.

III. Examples of Animals

- A. Hydras
  - 1. Spend lives as polyps.
  - 2. Live in fresh water.
  - 3. Move via somersaulting movement.
- B. Corals
  - 1. Soft-bodied organisms - Shapes: antlers, fans, brains.
  - 2. Use minerals in the water to build limestone skeleton.
  - 3. Form coral reefs
    - a. Extract calcium from water to build solid reef.
    - b. Great Barrier Reef off coast of Australia is an example of a reef.
    - c. Top layer of reef contains living corals.
    - d. Plant-like autotrophic algae (called zooxanthellae), live inside coral's body to create a symbiotic relationship.
- C. Sea Anemones
  - 1. Polyps that resemble underwater flowers.
    - a. Have tentacles that contain nematocysts.
  - 2. Fish swimming by are stung by the nematocysts.
- D. Jellyfish
  - 1. Most commonly recognized of all cnidarians.
  - 2. Deliver a painful poison through its nematocysts on its tentacles.
  - 3. Use its nematocysts to capture prey.
  - 4. Have both sexual and asexual stages in its life cycle.

Investigation: Life as a Jellyfish

Objective:

Students will demonstrate an understanding of the purpose and function of the body plan of the medusa form of cnidarians by actually constructing a jellyfish.

Materials:

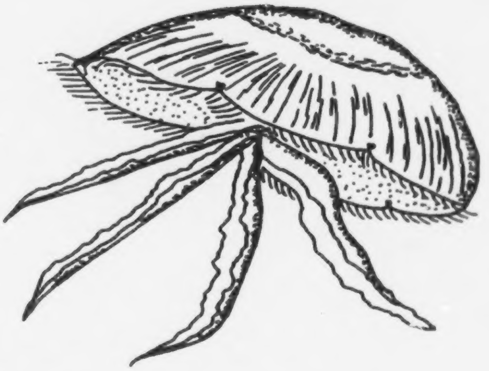
- Jello
- Plastic wrap
- String
- Container with water
- Paper clips
- Paper cups or similar containers

Background:

Jellyfish are one of the most complex and interesting brainless animals. It is hard to believe, while watching these creatures of beauty, that they have very simple nervous systems that are without brains. They possess the ability to move throughout the water column, ingeniously paralyze their prey with toxin-laden stinging cells, and, in some cases, even carry out a symbiotic relationship with algae which live inside their tissue.

Fun Facts:
There are over 3,000 species of jellyfish in the world. Most of them live in the ocean.

Perhaps what is most interesting about jellyfish, as with most cnidarians, is their remarkable passage through vividly different life stages. The jellyfish that glides through the water, at one point in its life is a sessile polyp that is firmly attached to a substrate. This lesson will help your students appreciate the unique body plan of a jellyfish by actually building a relatively realistic model of this amazing creature.



The jellyfish, Auriela, is found in the open ocean. Some species are found at depths of 3000 meters.

Procedure:

1. Ask students to describe some of the different shapes of jellyfish with which they are familiar. Ask them if they have ever seen jellyfish at the ocean or on television. Have them draw a jellyfish based on jellyfish they have seen.

2. After students have completed their drawings, ask them what they think jellyfish are made of. Ask them where the term "jelly"fish comes from. Then ask students what materials they would use in constructing models of jellyfish.

3. Inform students that you have gathered materials from which they can construct jellyfish of their choice. Since jellyfish are made of a gelatinous material, the basis for the internal body will be jello!

4. Mix up several batches of jello mix on a stove or a hot plate in the classroom. This should be done by the teacher and not the students. **Wear safety goggles or safety glasses when heating and pouring the jello mixture. Do not let students do this procedure!**

5. Students can choose the shape and size of the jellyfish by picking a container. Possibilities include paper cups, margarine dishes, whipped cream containers, or tupperware.

6. Before pouring the liquid jello mixture into the container, tie 5 to 9 pieces of string to a paper clip. These will serve as tentacles. Place the paper clip in the container with the strings going upward.

7. Pour the jello into the cup. After pouring the jello, carefully pull the paper clip up into the middle of the jello mixture suspended by the strings. Tie the strings to a pencil or ruler which rests across the top of the container.

8. Let the jello harden in a refrigerator for several hours or at room temperature over night.

Fun Facts:
Jellyfish live in all parts of the world. Some even live underneath the ice caps in Antarctica and the North Pole.

9. After the jello has hardened, gently and carefully remove it from the container.

10. Wrap the jello in a layer of plastic wrap surrounding the jello, tying it together around the tentacles. You now have a jellyfish.

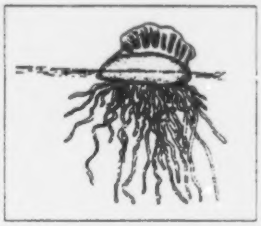
11. Float your jellyfish in the sink or aquarium. If it has a hard time floating, let a little air into the plastic wrap.

12. Students can modify their jellyfish to make them appear more realistic by altering the length of the tentacles, adding sails made of a small inflated zip-lock bags to look like a Portuguese-man-of-war, or coloring the plastic wrap with markers.

Assessment:

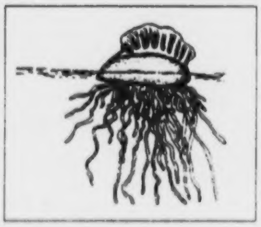
Students can write paragraphs explaining the body plan of a jellyfish accompanied by diagrams of the jellyfish labeling the body parts.

Students can also make a bulletin board display of different kinds of jellyfish.



Conclusion:

To conclude the lesson, ask students how their models are similar or different than a real jellyfish. Also ask them what some of the advantages and disadvantages are of the body plan of a jellyfish.



Cultural Connections: Belize - A Trip to Paradise

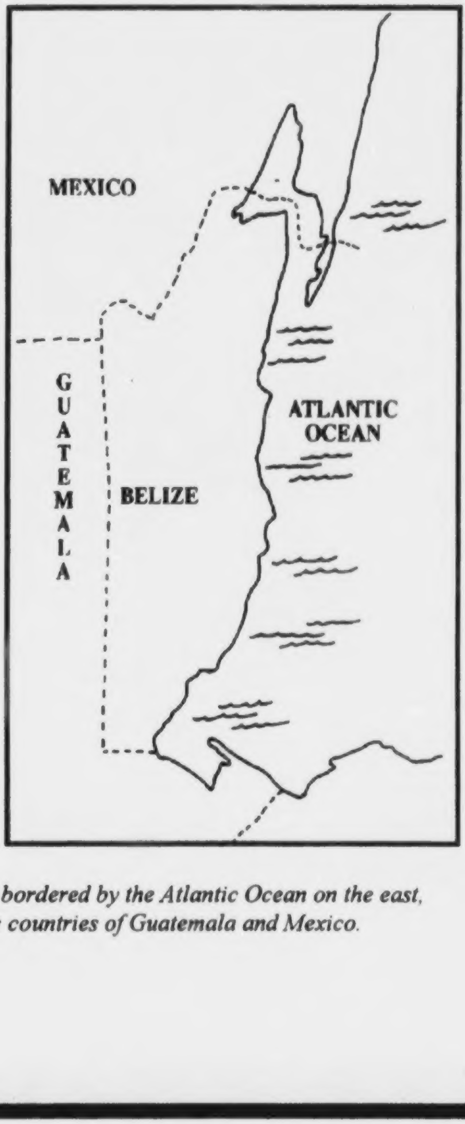
Belize is a small country in Central America that is only a couple hours by plane from Texas or Florida. It is a beautiful country full of nature and friendly people. One of Belize's main attractions is the country's coral studded barrier reef, a spectacular formation that runs along almost the entire 195-mile length of the coast and swings from within 10 to 40 miles of the mainland. It is the longest unbroken reef of living coral in the Western Hemisphere. It is second in the world only to the Great Barrier Reef in Australia.

The reef is one of the richest ecosystems on the planet and has hundreds of beautiful islands, sand bars, patch reefs, and various underwater structures that are home to dozens of animal and plant species. There are 220 types of fish and hundreds of types of invertebrates. The great variety of brightly-hued tropical fish that populate the reef are remarkable for their size and abundance. The outer wall of the reef is very popular among divers who explore the 120-foot drop-off.

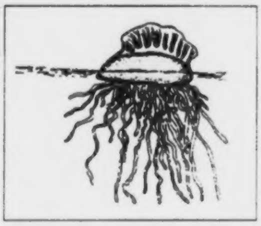
So rare and exquisite is the habitat, that the United Nations has proposed preservation of the reef as a World Heritage Site. Belize protects its precious marine life with the Hol Chan Marine Preserve off Ambergris Caye. The reef is thriving because of the steps Belize has taken to ensure its well-being. Belize intends to keep it that way for the enjoyment of present and future generations.

The people of Belize depend on the reef for food. Fish, conch, and lobster are just a few of the reef creatures which have fed the people of Belize for hundreds of years. But more recently the reef has "turned to gold."

Tourists from around the world come to see the ecology of the beautiful reef. This type of ecological tourism is referred to as "Ecotourism." It has brought much business to Belize and has helped the country to preserve its precious reef.



Belize, bordered by the Atlantic Ocean on the east, and the countries of Guatemala and Mexico.



Those Amazing Cnidarians!

Coral, hydra, jellyfish, and sea anemones are Cnidarians (formerly Coelenterates). There are over 9,000 species of cnidarians, with most found in salt water. What makes cnidarians so interesting is that most must go through two totally different life stages.

They have a polyp stage in which the animal is firmly anchored to something. They can also have a medusa stage in which the cnidarian floats freely in the water. Corals are examples of the polyp, whereas jellyfish are examples of the medusa. Corals spend their entire life in the polyp stage.

Cnidaria have radial, or round, symmetry. In the polyp stage, a round or cigar-shaped body has a mouth surrounded by tentacles. The medusa or jellyfish stage is shaped like an umbrella from which the tentacles suspend, with the mouth at the center of the body.

Cnidaria have a gastrovascular cavity in which food is digested. Food enters and leaves through the same opening. The mouth and anus are the same thing! The tissue of cnidarians is thin and can be jelly-like or firm. Up to 95% of a cnidarian's body may be water.

These animals have a nerve net, which is a very simple type of nervous system. They move by contracting simple muscle tissues. They do have the ability to sense and respond to light, heat, and mechanical, chemical, and gravitational stimuli. Even though cnidaria may appear to move about and even think, they do not have brains.

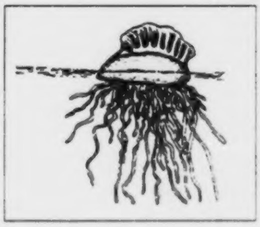
Prey is captured by the tentacles and is killed by poisons ejected by stinging cells called nematocysts. In some cases, the sting of corals or jellyfish can be very harmful to humans, and in some cases can cause death.

Cnidaria reproduce by both budding and sexual reproduction. Budding involves the growing and breaking off of a complete new animal that looks like its parent. Cnidarians can also regenrate lost or damaged body parts.

For the most part, people do not eat cnidarians. In fact, few animals eat them, except for the sea turtle which eats jellyfish. But cnidarians are very useful animals. Corals build massive reefs which provide a home for thousands of kinds of animals, including many we eat, such as lobsters and fish.

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

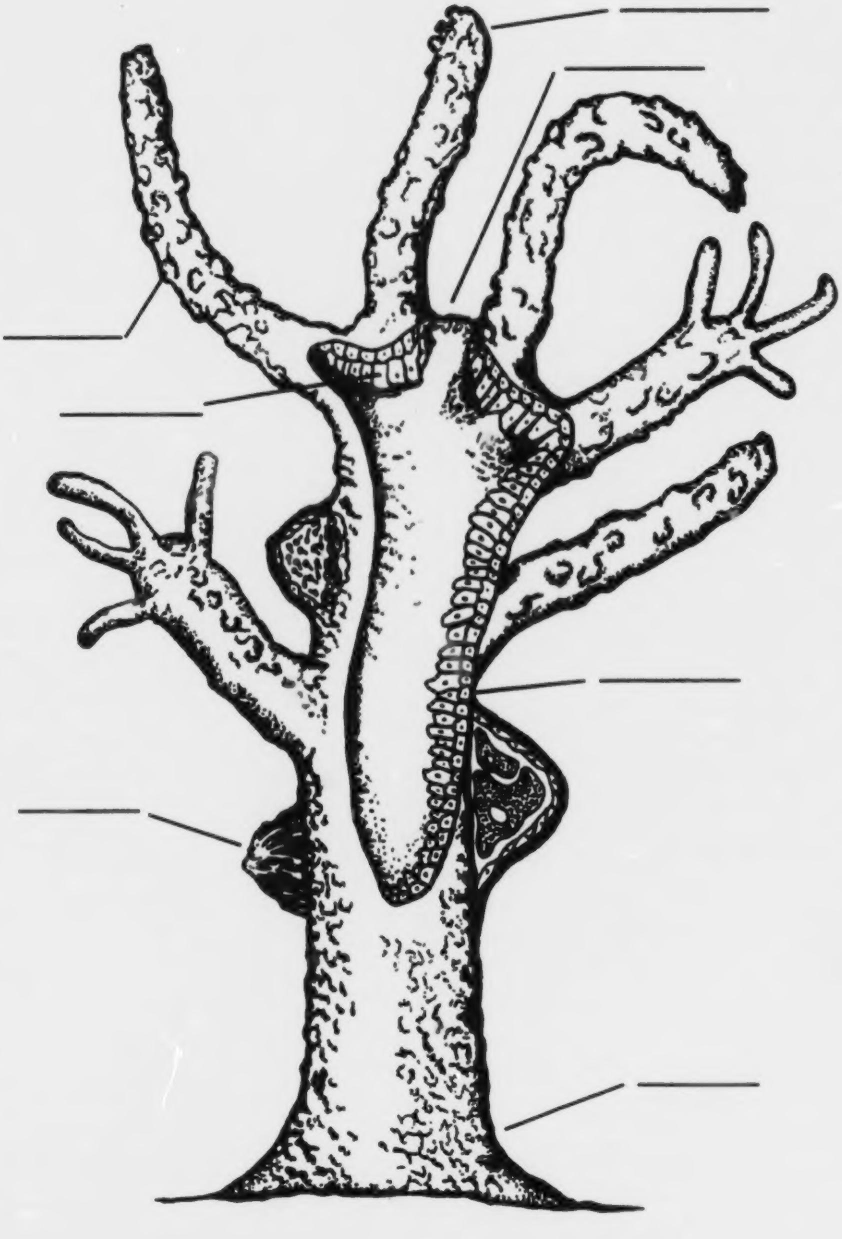
Polyp
Medusa
Gastrovascular cavity
Nerve net
Tentacles
Nematocyst
Budding



Name That Cnidarian

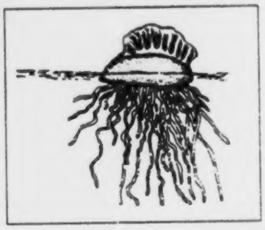
Using a biology book, a textbook or an encyclopedia, fill in the correct parts of this hydra. Color the cell layers, tentacles, and mouth different colors. Be creative and sketch a prey item which the hydra is in the process of capturing with its tentacles.

Fun Facts:
Freshwater hydra are unusual cnidarians in that they do not have a medusa stage.



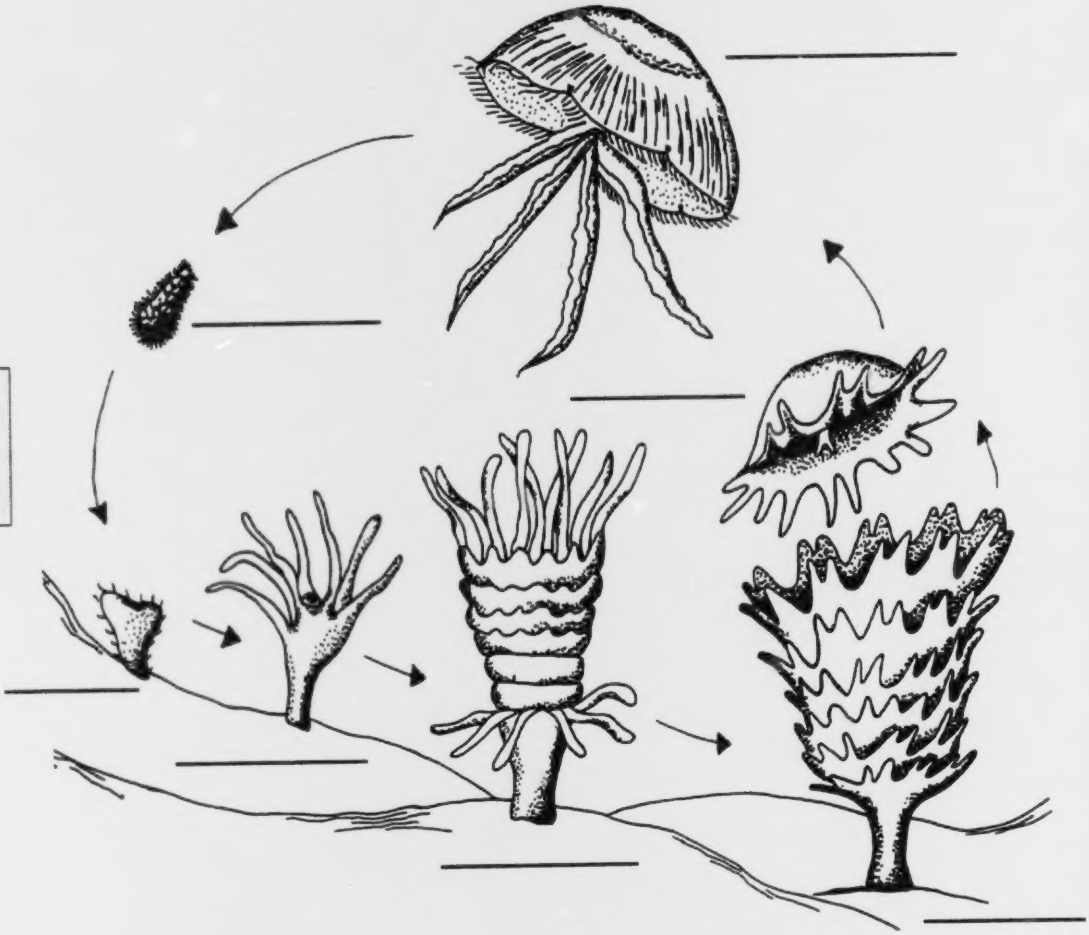
On a separate piece of paper, provide the definition, state the function, and then place the following terms on the correct line on the diagram:

- Base
- Tentacle
- Bud
- Endoderm
- Nematocyst
- Ectoderm
- Mouth

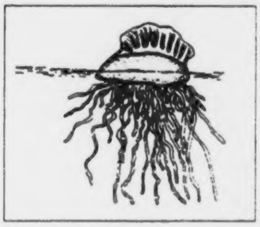


Growing Up Is Tough!

If you think growing up is tough, look at what cnidarians have to go through. Study the life cycle stages of this cnidarian,called an Auerelia. Color each organism, and then label the stage (Adult Medusa, Adult Polyp, Ciliated Larva, Young Medusa, Young Polyp, Ephyra, Planula).



Fun Facts:
Jellyfish may consist of up to 95% water!

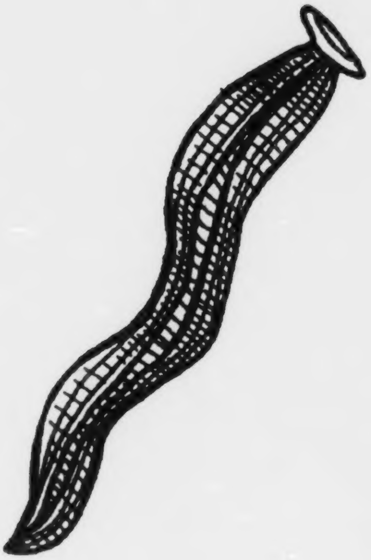


What is a Cnidarian?

Directions: Use textbooks, encyclopedias, and other science books to fill in the specific characteristics of Cnidarians.

Characteristic	Cnidarian Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	

Leeches are a kind of blood-sucking worm. They were used for medicinal purposes for many years. Today, the chemicals they produce are being used to prevent blood-clotting.



THE WORMS

This Unit Includes

I. For the Teacher:

- **Teacher Information**
  - *Unit Overview*
  - *Lecture Notes*
- **Teacher-Directed Activity**
  - *Investigation: Fantastic Flatworms*
  - *Investigation: Big Ones, Fat Ones, Itty Bitty Juicy Ones*

II. For the Student:

- **Student Information**
  - *Cultural Connections: The Guinea Worm*
  - *Those Amazing Worms!*
- **Student Activity**
  - *Data Page: Earthworm*
  - *Life Cycle of the Guinea Worm*
  - *What is an Annelid?*

Unit Overview

Organism Highlights

Worms are a diverse group of animals which are disliked by many people. Students will study three major phyla: Platyhelminthes (flatworms), Nematodes (roundworms), and Annelids (segmented worms). The activities and investigations are designed to give students a hands-on opportunity to study worms and to be exposed to their fascinating characteristics. This unit will help students develop an appreciation and understanding of worms.

Suggested Pacing Chart

Day 1:

1. Give a brief lesson/lecture on worms. Sample Lecture Notes are provided on page 32.
2. Students should read the Student Information Sheet, *Those Amazing Worms!* on pages 36 and 37 or the Blackline Masters.
3. For homework, define the terms at the end of the reading.

Day 2:

1. Conduct Teacher-Directed Activity, page 33, *Investigation: Fantastic Flatworms.* You will need to order live planaria ahead of time.

Day 3:

1. Have students do Teacher-Directed Activity, *Investigation: Big Ones, Fat Ones, Itty Bitty Juicy Ones,* on page 34. Either you or your students will need to get some live earthworms.
2. Student observations from the investigation should be recorded on Student Activity, *Data Page: Earthworm,* on page 38 or the Blackline Master.

Many leeches are predators, feeding on the blood and soft tissue of their prey.

Day 4:

1. Have students read *Cultural Connections: The Guinea Worm*, on page 35 or the Blackline Master.
2. Students should then complete the Student Activity, *Life Cycle of the Guinea Worm,* on page 39 or the Blackline Master.
3. Discuss the life cycle of the worm and answer the questions as a class or individually.
4. To conclude the unit, students should complete Student Activity, *What Is an Annelid?* on page 40 or the Blackline Master.

Links to National Science Education Standards:

1. Science as Inquiry

"Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument." Develop Descriptions, Explanations, Predictions, and Models Using Evidence, Grade 5-8

2. Life Science

"Living systems at all levels of organization demonstrate the complementary nature of structure and function." Structure and Function in Living Systems, Grade 5-8

3. Science in Personal and Social Perspectives

"Natural environments may contain substances that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air." Personal Health, Grade 5-8

Interdisciplinary Connections:

Language Arts

To many people, worms are not very pleasant animals to think about. They stir up images of dirt, slime, and mucous. As a creative writing exercise, capitalize on these vivid thoughts and feelings by having students write a poem or short story about worms. For example, write a poem about putting a worm on a fish hook, or write a short story about leeches. An Australian worm farm, noted below, has some suggestions for submitting "pet worm" stories to their internet website. The possibilities for worm writing are endless.

Mathematics

Two worm-borne diseases are discussed in this unit: Guinea Worm disease and Schistosomiasis. The World Health Organization has a great deal of data on these diseases. The data can be easily located on the internet addresses listed below. Access this data, provide it to students, and discuss it in class. The data can be graphed to see how the diseases have changed throughout time, and how they vary between different countries.

Social Studies

The article titled *Cultural Connections: The Guinea Worm,* on page 35, has numerous applications to health problems throughout the world. Students can study this issue in greater detail, or pick other serious health problems, such as malaria or cholera. The various social and economic factors leading to these health problems throughout the world can be the focus of a class discussion or research project.

Surfing the Web:

1. http://www.nysaes.cornell.edu/ent/biocontrol/paathogens/nematodes.html
Cornell University's website discusses some of the beneficial and harmful nematodes. It emphasizes biological ways to control and promote roundworms, accompanied by nice images.

2. http://www.york.biosis.org/zrdocs/zoolinfo/grp_nem.htm
This homepage provides a comprehensive list and links to platyhelminthes, nematodes and other worm-related websites.

3. http://www2.eis.net.au/~kez/worms.html
This website from Australia features a commercial worm farm. It contains a lot of interesting information about earthworms.

4. http://www.who.org/programmes/ctd/diseases/shis/shismafr.htm
The World Health Organization website provides excellent up-to-date information on Schistosomiasis and links to other diseases.

Assessment:

Students will produce numerous portfolio assessment pieces in this unit, such as earthworm diagrams and drawings of regenerated planaria. Their understanding of flatworm life cycles is also assessable with the diagram *Life Cycle of the Guinea Worm* on page 39 or the Blackline Master. Students can 3-hole punch these items and place them in their notebooks. The terminology associated with worms can be assessed by having students create annotated labeled diagrams of other common worms.

Resources:

Buschsbaum, Ralph. *Animals Without Backbones.* University of Chicago Press, Chicago, 1972.
Drancunoculiasis, Control of Tropical Disease Series. World Health Organization, 1993.
Let Not the Sinuous Worm Strike Me . . . The Carter Center, (404) 331-3900.
Video - *Animals Without Backbones: The Invertabrate Story.* United Learning. Niles, IL,1-800-424-0362.

Lecture Notes

I. Background on Worms

- A. Thousands of species in a wide variety of shapes and sizes.
- B. Inhabit water, soil, inside trees, and even insides of animals, including people.
- C. Valuable contributors to environment, but can also be pests to agriculture and spread disease to people.
- D. Three major phyla: Platyhelminthes (flatworms), Nematodes (roundworms), and Annelids (segmented).

II. Platyhelminthes (also called flatworms)

- A. Flat body with bilateral symmetry.
- B. Simplest of the worms.
- C. Examples include planaria and flatworm (draw planaria on chalkboard).
- D. No true body cavity and no extensive organ development.
- E. Anterior end (head).
    - 1. Specialized for sensory perception.
    - 2. Ganglia on sides for sensing physical stimulation.
    - 3. Eyespots for sensing light.
    - 4. Mouth which serves as entrance and exit of food and waste.
        - a. Have pharynx which is extended to gather microscopic food particles.
- F. Nervous System.
    - 1. Consists of network of large ganglion.
    - 2. Eyespots to sense light.
- G. No circulatory system and no blood.
- F. Reproduction.
    - 1. Asexually by binary fission, and by regeneration.
    - 2. Possible to create two-headed planaria, which eventually splits apart into two organisms.

III. Nematodes (also called roundworms)

- A. Round, tapering body with bilateral symmetry.
- B. More advanced than flatworms.
- C. Over 12,000 known species (ex. vinegar eels, hook worms, trichina).
- D. Digestive System.
    - 1. Mouth at one end and anus at posterior end for one-way passage of food.
    - 2. Also have pharynx and intestine.
- E. Reproduction.
    - 1. Only reproduce sexually and have separate sexes.

IV. Annelids (also called segmented worms)

- A. Bodies with segments and bilateral symmetry.
- B. Leeches, earthworms, and bristle worms are among most familiar.
- C. Covered with mucous and tiny hairs called setae for movement.
- D. Tube-within-a-tube body plan - internal organs are separated from other body parts.
- E. Digestive System.
    - 1. Esophagus transports food to following: crop for storage, gizzard for grinding, and intestine for digestion.
    - 2. Castings - entrails of worms that contain important soil nutrients.
- F. Circulatory System
    - 1. Contains blood vessels.
    - 2. Five pairs of "hearts" which pump blood.
- G. Nervous System
    - 1. Simple brain with ganglia (each segment contains a ganglia).
    - 2. Poorly developed sensory organs.
- H. Reproduction
    - 1. Hermaphroditic.
    - 2. Sex organs located in clitellum.

Investigation: Fantastic Flatworms

Objective:

Students will have the opportunity to learn about flatworms by observing a live planaria. In addition, they will see how the process of regeneration enables them to reproduce and adapt to their environment.

Materials:

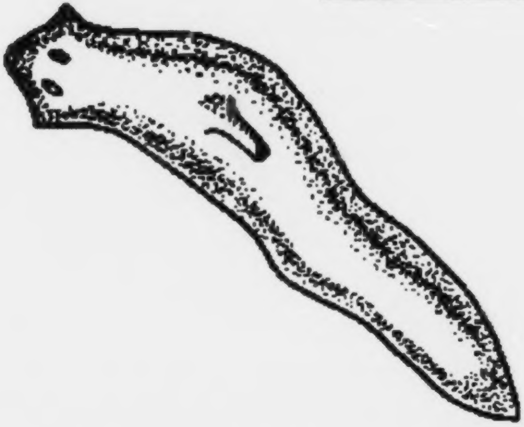
- Live planaria (optional) or diagram of planaria
- Dissection microscope

Background:

One of the most extensively studied worms is the planaria. This flatworm, found commonly in freshwater environments, is considered a good representative of the phylum. Planaria can be found in most freshwater environments in North America. But they are very small and often go unnoticed. The easiest way to obtain planaria is to order them from a scientific supply company. If you choose not to order planaria, then have students observe a diagram of planaria, such as the one provided.

Procedure:

1. Live planaria can be ordered through a scientific supply company at a relatively low cost per class set. They are well worth the money and your students will get a kick out of them. Before your planaria arrive, you should set up your classroom with microscopes, slides, petri dishes or watch glasses, and tweezers or probes.
2. Before the animals arrive, give your students a brief lecture on the phylum Platyhelminthes. Students should be familiar with the general body plan of planaria.
3. When the animals arrive, store them in a dark place until ready to use. Student groups can select their planaria and place them in a petri dish, watch glass, or a microscope slide. Put the planaria in a couple drops of water.
4. Students can view the organisms with dissecting or compound microscopes. They should observe the shape, color, and movement of the planaria. Have them make diagrams of the planaria and label the head, eyespots, auricles, and tail.
5. Instruct students to lightly touch the end of the auricles. Observe the result. Decide whether the head or tail is more sensitive.



Planaria are small flatworms. They prefer fresh water, such as streams, lakes, and pools.

Assessment:

The diagrams of the planaria and the ability to describe the function of its body parts serve as a means to assess student understanding.

Conclusion:

Ask students how flatworms are uniquely designed to carry out their lives. Also discuss how these animals are limited by the amount of activity they can conduct and how this is a disadvantage.

Investigation: Big Ones, Fat Ones, Itty Bitty Juicy Ones

Objective:

Students will investigate an exemplary annelid by studying a real, live earthworm.

Materials:

- Earthworms (students can bring them from home or you can buy worms from a bait shop or scientific supply company)
- Dish, plate or pan to hold live earthworm
- Paper towels
- Magnifying glass or dissecting microscope

Background:

Earthworms are common annelids found throughout North America. Students can see the segments of an earthworm, which are characteristic of the annelids. Annelids are the most advanced worms. They have three tissue layers and a tube-within-a-tube body plan. They have simple circulatory, nervous and muscular systems. In this investigation, the students study the external anatomy and movement of earthworms. They will identify the mouth, anus, clitellum, setae, and segments of a common worm.

Procedure:

1. Store earthworms in a cool, dark, damp container. Students can then put them on wet paper towels or in dishes with a small amount of water.

2. Students should observe how the earthworms move, and then record what they see on *Data Page: Earthworm* on page 38 or the Blackline Master.

3. Next, students will study the body features of the worms. They should identify the mouth, anus, segments, and clitellum. Ask them how many segments the worms have. Ask them to measure the length of the worms.

Earthworms prefer to live in moist, rich soil, emerging after dark to explore their surroundings.

4. Using a magnifying glass or a dissecting microscope, students can identify the setae. These are tiny hairs located on the segments. Students should describe what they think the setae are used for.

5. Students should complete *Data Page: Earthworm* on page 38 or the Blackline Master, and then free the worms into the soil!

6. Have a class discussion asking students what type of habitats the worms live in. Ask how the bodies of worms are designed to successfully live in their habitats.

Assessment:

Students can take their data sheets home to obtain additional information from other sources to elaborate on their answers. Students can also write a paragraph explaining how the earthworm's body structure enables it to live its life so efficiently.

Conclusion:

Ask students how the three major worm groups differ from each other. Compare the different body systems, such as digestive, circulatory, nervous, and reproductive systems. Based on this discussion, describe which worms are considered most advanced. Have students use a biology text or encyclopedia to study the internal organs of earthworms. Discuss how their internal organs are similar and dissimilar to ours.

Cultural Connections: The Guinea Worm

Guinea worm disease, or dracunculiasis, is a parasitic disease caused by a nematode which affects about 10 million people in 19 African and Asian countries. It is transmitted to humans when they drink water that contains infected copepods (water fleas), which act as the intermediate host. It is a devastating and crippling disease that occurs most often in poor agricultural communities. More than 120 million people are believed to be at risk of infection.

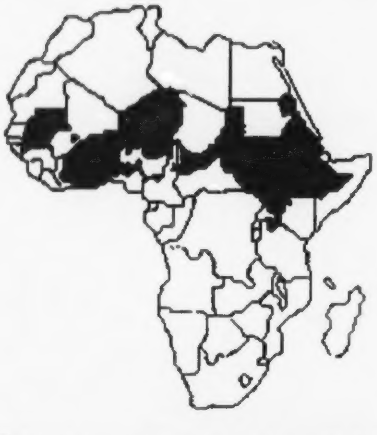
People with the disease feel weak and are not able to do work sometimes for several months. This is a big problem for farmers who need to work to provide food for their families. The economic impact to areas of Africa and Asia affected by the Guinea worm can be devastating.

People become infected when they drink water contaminated with infected copepods. These water fleas are usually found in wells, ponds or other stagnant bodies of water. Infective larvae of the parasite contained within the copepod are released into the human intestine. The larvae migrates to deep body tissues where they mate. The male worm has no further role beyond reproduction.

No symptoms occur during a one-year incubation period. Once it has reached maturity, the now one-meter (about 3 feet) long female worm migrates to a position under the skin, most often the leg, where she creates a painful, burning blister. Eventually the blister breaks, exposing the head of the worm. When the infected person washes his leg in water to soothe the pain, the worm releases thousands of first-stage larvae. If the worm is not extracted immediately, it will continue to expel larvae whenever it comes in contact with water. These larvae may be ingested by copepods and mature to the infectious stage, usually in two to three weeks. They continue the cycle by infecting the next person who ingests them in drinking water.

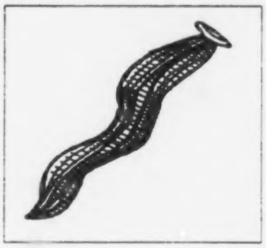
Despite the gloomy picture of the Guinea worm disease, it is rarely fatal. Measures to prevent it are inexpensive and extremely effective. The methods that will be used to control the Guinea worm disease include health education, protection of drinking water sources, and filtering copepods out of the water, or destroying them with heat or chemicals. Current research efforts focus on improving the impact of these methods in the agricultural communities. There is no tropical parasitic disease that has more potential for control or eradication than the Guinea worm disease. In fact, there is great hope that the disease can be eliminated around the world within the next decade.

Distribution of Guinea Worm Disease in Africa



Guinea worms are common in central Africa.

Those Amazing Worms!



There are thousands of different kinds of worms that come in a variety of shapes, sizes, and colors. While we tend to think of worms as slimy pests, they are valuable contributors to earth's ecology.

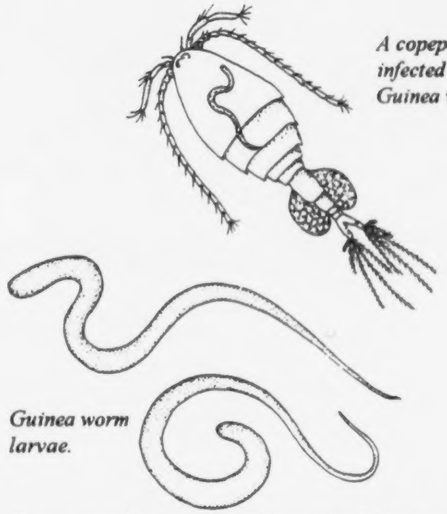
Platyhelminthes, or flatworms, have a flat body with bilateral symmetry. Some of the most familiar flatworms are planaria and tapeworms. Flatworms are found in almost every kind of environment, on land and in fresh and salt water. Many flatworms are parasitic and often display a complicated life cycle, which may require development in four or five hosts before completion.

Flatworms have no true body cavity; the spaces between the organs are filled with a compact connective tissue called parenchyma. Except in the simplest forms, one end of the body looks like a head. At this end is a mouth through which it extends a feeding tube called a pharynx. This draws in microscopic food particles and is also the tube through which waste matter is excreted.

Fun Facts:

Nematodes are one of the most abundant organisms on earth. There may be over 100 million nematodes per square yard of soil.

The nervous system consists of a network with a large ganglion, or nerves. "Eyespots" may be present. They are not really eyes, but allow the animals to sense light changes. The flatworm has no blood or circulatory system. Although flatworms are almost all hermaphroditic (both male and female reproductive organs are present in each individual), the eggs and sperm are formed separately. Flatworms are able to reproduce asexually, both by binary fission - by pinching themselves apart to become two - and by regeneration - producing an entire new worm from a piece that has been cut off.



A copepod that is infected with a Guinea worm larvae.

Guinea worm larvae.

Some parasitic worms, such as the Guinea worm, cause serious public health problems in many less developed areas. People become infected with Guinea worm disease when they drink water containing copepods that are infected with larvae of the worm.

Nematodes, or roundworms, are found in great numbers both on land and in water. Roundworms have a round, tapering body. Nematodes are considered to be more advanced than flatworms. This is because they have separate sexes, and have a more complex digestive system. Their digestive system is like a hose, with the mouth at one end, and the anus at the other end. Food enters one end and comes out the other end as waste.

Roundworms are found throughout the world and are very common in soil. There are over 12,000 known species, with perhaps thousands yet to be discovered. Many of them are harmful to crops and to humans. They live as parasites in plants and animals, including humans. One relatively common human parasite is the hookworm.

Those Amazing Worms!

Annelids are often called segmented worms because their bodies are divided into dozens of individual segments. Leeches, earthworms, and bristle worms are among the most familiar annelids. Most have a slimy feel because they are covered with mucous, which helps them move and allows gases to pass through their skin. They also have many tiny hairs, called setae, which act as little hooks pulling them along.

Annelids are more advanced than flatworms and roundworms because, for instance, they have a more advanced digestive system. They have a tube-within-a-tube body plan. This means that their internal organs are separated from other body parts.

Fun Facts:
Worm castings contain as much as 5 times more nitrogen and 7 times more phosphorus than ordinary topsoil.

The gut is a straight tube with an esophagus, a crop for storage, and a gizzard for grinding up food. They have an intestine that runs the length of the body and expels undigested food from the anus.

You may have seen the waste from worms on the ground, which are called castings. These are high in nutrients and minerals and help improve the soil. Earthworms also improve the soil by creating tunnels which allow gases to enter and exit the ground.

Earthworms feed mainly by passing soil through their bodies to extract nutrients, enriching and aerating the soil and thus playing an essential role in soil ecology.

Annelids have special tubes called vessels which carry blood. Earthworms, for example, have five pairs of structures which pump blood and act like our heart.

The nervous system is simple with a small brain and poorly developed sensory organs. The head may have eyes or bristles for feeling.

Earthworms are hermaphrodites, meaning they possess both sex organs. Both sperm and eggs are located in a widened band called the clitellum, which can be seen on most earthworms.

Another interesting type of annelid is the leech. Most leeches suck the blood of other animals to get their food. This is quite painless because they have a type of anesthesia which they send out while sucking blood.

For hundreds of years, leeches have been used by physicians to rid the body of harmful impurities. While this is not a common practice today, leeches are still used medically for bloodletting, and an extract prepared from their blood is used as a way to stop bleeding.

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

Platyhelminthes
Setae
Pharynx
Ganglia
Nematode
Eyespots
Regeneration
Annelid
Crop
Gizzard
Esophagus
Intestine

Data Page: Earthworm

1. Place your earthworm gently on a piece of wet paper towel. Take a few minutes to observe how the earthworm moves. Describe its movements in the space below:

____

____

2. Describe the symmetry: ____________________________

3. How can you tell the difference between the head (anterior) and tail (posterior) of your worm?

____

4. Count the number of body segments and record your answer.

____

5. Check with some other people in the classroom and write down the number of body segments they counted. __________ __________ __________

6. Rub your finger gently along the worm and feel the tiny bristles called setae. With a magnifying glass, try to find them. How many do you count on each body segment? __________

7. What do think is the function of the bristles?

____

8. Look closely to see if you can see blood pumping through the dorsal (back) blood vessel. Record the number of pulses per minute. ________________

9. From the head, go about a third down the earthworm. Look for a slight bulge in the body. This is the clitellum, where the reproductive organs are located. At what body segment is the clitellum located? ____________________

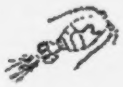
10. Create a diagram of your earthworm below. Label the following features: mouth, anus, segment, setae, and clitellum.

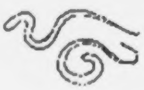
Life Cycle of the Guinea Worm

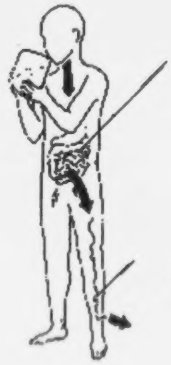
There are many different types of harmful flatworms. Many of these worms actually live inside the body as parasites. We call an organism in which a parasite lives a host. Some flatworms live in one or more hosts during their life cycles. One flatworm that has more than one host is the *Guinea worm*.

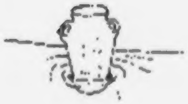
Below are pictures of the different phases in the Guinea worm life cycle. Also included are captions which describe the life cycle. Your task is to cut out the pictures and place them in the correct order with the correct captions. Glue the pictures and captions to a piece of paper. Color the different stages in the life cycle of the worm.

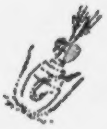
Pictures:

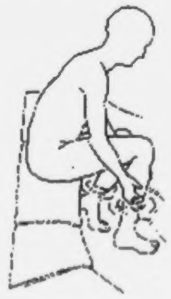












Captions:

Head of worm protrudes through blister

Copepod becomes infected with larvae

Microscopic copepods are ingested in drinking water

Mature female, up to one meter long, migrates to limb

Larvae released from inside copepod to intestine

Larvae released into water from worm coming out of blister

Larvae migrate to loose tissue and mature into adults

What is an Annelid?

Directions: Fill in the specific characteristic of Annelids in the right column.

Characteristic	Annelid Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	

Clams are among the most widespread and most common of all mollusks.

THE
MOLLUSKS

This Unit Includes

I. For the Teacher:

- **Teacher Information**
  - *Unit Overview*
  - *Lecture Notes*

- **Teacher-Directed Activity**
  - *Investigation: The Shell Game*
  - *Investigation: Squirting Squid*

II. For the Student:

- **Student Information**
  - *Cultural Connections: Mollusks and Native Americans*
  - *Those Amazing Mollusks!*

- **Student Activity**
  - *What is a Mollusk?*

Unit Overview

Organism Highlights:

Mollusks are a group of animals you are familiar with if you enjoy eating oysters, clams, mussels, or scallops. They are the second largest group of animals, next to the arthropods. Most students have seen either live mollusks or their shells. The investigations and activities in this unit enable students to learn about the major features of this group while actually getting a first-hand look at some interesting mollusks in your classroom.

Clams, along with mussels and oysters, are filter-feeding bivalves.

Suggested Pacing Chart:

Day 1:

1. Give a brief lesson/lecture on the Mollusks. Lecture Notes are provided on page 44.
2. Students should read Student Information Sheet, *Those Amazing Mollusks!* on page 49 or the Blackline Master. Define the vocabulary words at the end of the article in class or for homework.

Day 2:

1. Conduct Teacher-Directed Activity, *Investigation:The Shell Game* on pages 45-46.
2. For homework, students can write up the activity or read *Cultural Connections: Mollusks and Native Americans* on page 48 or the Blackline Master.

Day 3:

1. Do Teacher-Directed Activity, *Investigation: Squirting Squid,* on page 47.
2. For homework, students can complete Student Activity, *What is a Mollusk?*on page 50 or the Blackline Master.

Links to National Science Education Standards:

1. Science as Inquiry

"Students should think critically about evidence, including deciding what evidence should be used and accounting for anomalous data." Think Critically and Logically to Make the Relationships Between Evidence and Explanation, Grade 5-8

2. Life Science

"Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive." Regulation and Behavior, Grade 5-8

3. History and Nature of Science

"In historical perspective, science has been practiced by different individuals in different cultures." History of Science, Grade 5-8

Interdisciplinary Connections:

Language Arts

Write a poem or short story about a mollusk. Students can choose a snail, clam, mussel, squid, or octopus. They can write about the animal as an outsider experiencing the animal or as if the animal were telling a story about its life. The story can occur in the present or past.

Mathematics

From the data gathered in Teacher-Directed Activity *Investigation: The Shell Game* on pages 45-46, some simple statistical analysis can be conducted on the class data. For example, simple averages, mean, and mode can be computed for shell length, width, and growth rings for a given type of shell. Data from different types of shells can also be compared. Students should be challenged to derive meanings and explanations about the shells from the data. Focus the data analysis on the question: What stories do the numbers tell?

Social Studies

After reading *Cultural Connections: Mollusks and Native Americans* on page 48, discuss with students the important role mollusks play in Native American culture. You can expand the discussion by considering the role mollusks play in other cultures.

Surfing the Web:

1. http://www.york.biosis.org/zrdocs/zoolinfo /grp_moll.htm

Mollusca is a great starting point for links to dozens of mollusk-related websites.

2. http://www.ummz.lsa.umich.edu

This website form the University of Michigan illustrates some of the unusual features of mollusks accompanied with photographs and diagrams.

3. http://www.wh.whoi.edu/history.html

This brief site provides some glimpses into the past methods of fishing for mollusks, as well as other seafood. Archival photographs and descriptions of oysters, clams and scallops.

4. http://coa.acnatsci.org/conchnet/

The Conchologists of America site is for students who are interested in learning the hobby of shell collecting. It includes up-to-date information about meetings and activities.

Assessment:

In this unit, students conduct two hands-on investigations that illustrate some fundamental features of mollusks. Student understanding of these features can be assessed through their laboratory reports and diagrams.

Students also produce other portfolio assessment pieces in this unit, such as vocabulary lists, comparative grids, and models of squid. Students can expand their knowledge of mollusks by researching their favorite mollusk food items. They can find out where all those mollusks in the fish market come from, how they grow, and how they are netted.

Resources:

Emerson, William K. and others. *The American Museum of Natural History Guide to Shells: Land, Freshwater, and Marine, from Nova Scotia to Florida.* Knopf, 1976.

Gosner, Kenneth. *A Field Guide to the Atlantic Seashore*. Houghton-Mifflin, Boston, 1978.

Keats, Henry. *Beachcomber's Guide: From Cape Cod to Cape Hatteras.* Gulf Publishing, 1995.

Rehder, Harrold, A. *The Audubon Society Field Guide to North American Shells.* Knopf, 1981.

Stachowitsch, Michael. *The Invertebrates: An Illustrated Guide*. Wiley-Liss, 1992.

Video - *Animals Without Backbones: The Invertebrate Story.* United Learning. Niles, IL. 1-800-424-0362.

Lecture Notes

I. Background on Mollusks

- A. Mollusk comes from the Latin word *molluscus* meaning "soft"
  - 1. Soft-bodied animals with a shell.
- B. Over 100,000 species plus over 35,000 fossil species.
- C. Live both in water and on land.
- D. Three main groups:
  - 1. Two-shelled - Bivalves.
  - 2. Snails and slugs - Gastropods.
  - 3. Tentacled mollusks - Cephalopods.

II. Characteristics

- A. External shell (clams, oysters, mussels, and snails) or internal shell (squid and octopus).
  - 1. Shell secreted by mantle and made of calcium compounds.
  - 2. Protects soft tissue and organs.
- B. Muscular Foot - used for movement or to dig through sand.
- C. Head - mouth, eyes, and sensory organs.
- D. Visceral mass - soft tissue that contains haert, digestive, excretory, and reproductive systems..
  - 1. Mantle - produces the shell and covers the visceral mass.
  - 2. Stomach - digests food.
- E. Reproduction - reproduce sexually.

III. Gastropods

- A. Examples include snails and slugs.
- B. Live on land and water.
- C. Have radula in their mouths.
  - 1. Looks like a file used to shave wood.
  - 2. Used to bite off or scrape food.
- D. Slugs and snails move by a muscular foot that is usually covered with mucus.

IV. Two-Shelled Mollusks - Bivalves (2 valves)

- A. Examples include clams, oysters, scallops, and mussels.
- B. Shell usually made of calcium carbonate excreted by mantle.
- C. Use muscular foot for movement, attachment, or for jet propulsion.
  - 1. Some species of clams use foot to dig deep into sand or mud.
- D. Filter feeders - siphon plankton through body, which they capture and eat.

V. Mollusks with Tentacles - Cephalopods (means head-foot)

- A. Examples include squid, octopus, and nautilus.
- B. Most well-developed of the mollusks.
  - 1. Possess eyes and can sense light and objects.
  - 2. Are well coordinated.
    - a. Squid can catch fish at high speeds.
    - b. Octopi are very intelligent animals that can learn behaviors.
- C. All have tentacles - many use them to catch prey.
- D. Squid and nautiluses are excellent swimmers and move via jet propulsion of water.
- E. Squid and octopus can also protect themselves by ejecting dark clouds of ink or via camouflage.

Investigation: The Shell Game

Objective:

Students will learn how mollusks function by looking at different shells, and interpreting how their shells provide clues to the specific habitat.

Materials:

- Shells - clams, oysters, mussels, scallops

Background:

Most of us have seen and probably eaten mollusks, such as clams, mussels, oysters, or scallops. These delicacies are all bivalves, meaning they have two shells. They are found in both fresh and salt water throughout the world. When you eat a bivalve, you are eating the soft tissues of the animal, not the shell. When bivalves die, the soft tissue quickly degrades, but the calcium carbonate shell may exist for hundreds or thousands of years. The shells can tell us an amazing amount about the once-living animal. It can give us clues about the general type of environment the animal may have lived in. From a shell, we can also identify the location of the adductor muscle, the palial sinus, right or left valve, and even determine an estimation of its age.

Fun Facts:

Pearls are formed in bivalves when a bit of sand or parasite becomes covered with a hard, shiny material called nacre.

Procedure:

1. Begin by drawing a diagram of a clam shell on the chalkboard similar to the one on the following page. Label the following parts: umbo, ligament, adductor muscle scar, pallial sinus, and pallial line.

2. Discuss the function of these structures.

Many clams burrow into soft mud with their strong muscular foot. They then use a siphon to take in water.

3. Provide students with a clam shell (one valve, or half, is all that is needed). Have them figure out whether they have a right or left valve. To determine this, they must hold the convex part of the shell in the palm of their hands. If the umbo points toward them, they need to switch it to the other hand. Once it is in the correct hand, it is called a right or left valve, depending on whether it is in the right or left hand.

4. Students can then find a shell which matches theirs to make a complete clam (right and left valves).

5. Instruct students to create a diagram illustrating the inside of their shells. They should label the

umbo, ligament, adductor muscle scar, pallial sinus, and pallial line.

6. Have them match their valves together so they can see how adductor muscles attach to both shells.

7. Next, have them identify the growth lines. Explain that new growth occurs along the outer lip.

8. Provide students with different types of bivalves, such as mussels, scallops, and oysters or any other bivalves you can obtain. You can give student groups a collection of shells, or set the specimens up at numbered stations throughout the room.

9. Explain to students that we can tell a lot about a bivalve just from its shell. For example, a thick shell means the animal probably lived in an area where it needed a lot of protection from waves and currents. A thin shell may indicate it lived in soft mud. An elongated shell is designed for deep burrowing.

10. Have students make a sketch of the different bivalves, and identify whether they are mussels, clams, scallops, or oysters. They should also describe the type of environment in which they think the animals once lived.

Assessment:

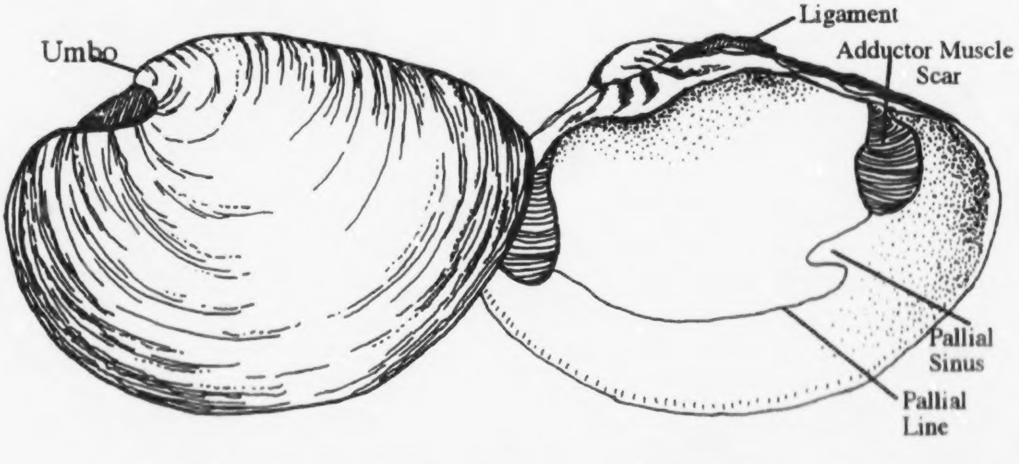
Students should develop an illustrated guide to their shells. The guide should include labeled diagrams as well as a couple of sentences describing the habitats they believe were home to their bivalves. Excerpts from these guides can be posted on bulletin boards.

Conclusion:

Conclude the lesson with the following game: Give each student team a description of a bivalve on a piece of paper. The description should contain a few clues, but not too many. For example, a scallop shell might have the following clues:

- cannot tell the difference between right and left valves
- taste great

Students then need to go around the room to find the bivalve that meets the description. You can then have students trade clues and try to find another bivalve. You can time each trial to see who finds the bivalves in the least amount of time.



The above diagram illustrates the different parts of a clam shell.

Investigation: Squirting Squid

Objective:

Students will explore how a squid moves and eludes predators.

Materials:

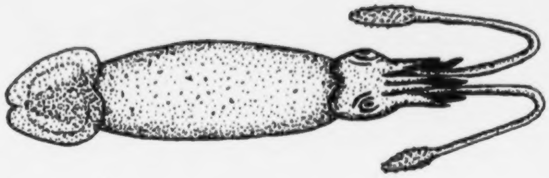
- Balloons
- Blue food coloring
- Bucket or sink with water
- Squid (optional)

Background

Squid are one of the more remarkable mollusks. With an internal shell, they have incredible agility in water, swimming with great grace and speed. Long tentacles are used to capture fish, which it pulls toward the mouth and then paralyzes by biting the spine with its teeth-like beak. Utilizing jets of water, it can propel itself forward and backwards to rapidly catch prey. Typically, when threatened, they retreat rapidly backwards, ejecting a dark cloud of ink to confuse predators.

Procedure:

1. Discuss the information conveyed in the Background section with students.
2. If time permits, buy a squid at the fish market and bring it to school to show students. Most students probably have never seen a squid and will be quite amazed. Point out structures such as ink sac, pen, and beak.
3. Provide each student group with a large balloon. Explain to students that they will develop a demonstration of a squid in motion. They should put a few drops of blue food coloring in their balloon.
4. Next, they should carefully fill up the balloon with water. **Instruct students that they are not making water balloons to throw at each other!**
5. Holding the end of the balloon, gently lower it in a bucket or sink full of water. Then let go of the balloon and observe what happens.
6. Instruct each student to write a paragraph about their observations and explanations of what caused the balloon to move. If time permits, they can create diagrams of before and after the balloon moved.



Squid are among the most advanced mollusks. Like cuttlefish, they have a small internal shell.

Assessment

The paragraphs students write explaining their observations and explanations of the moving balloon can serve as assessment pieces. It might be instructive to write a paragraph together as a class. You can write it sentence by sentence on the chalkboard or overhead projector.

Conclusion

Conclude the lesson by asking students how the streamlined body of a squid enables it to swim rapidly. Discuss how the body of a squid looks vastly different compared to that of other mollusks.

Cultural Connections: Mollusks and Native Americans

Mollusks have played an important role in Native American culture for thousands of years. Wherever there was water, there were abundant mollusks. Lakes, rivers, and the ocean provided habitat for clams, mussels, oysters, and snails. Not only did Native Americans eat mollusks, but they used them as social, economic, and religious objects.

Native Americans living on the east coast of North America were blessed with an abundance of mollusks. For example, the Powhatans, who dwelled along the shores of the Chesapeake Bay, consumed tremendous amounts of oysters and clams. Through archaeological work, it is estimated that their diets had one of the highest percentages of protein of all Native American groups.

Fun Facts:
Many of the highest points in South Florida consist of oyster shells discarded by Native Americans.

In Florida, the Seminoles ate so many oysters that large mounds were made from the discarded shells. The mounds still exist today. In many cases, the mounds are the highest point for miles around!

It was common practice to make jewelry from the shells of mollusks. Clams, mussels, and conch shells were made into beautiful beads and pendants. In some cases, designs were etched into the shiny surface of shells. Pearls derived from oysters or conchs were also worn as jewelry or to decorate festive clothing.

Mollusks were also used as building materials. Clay was often mixed with shell fragments to strengthen pottery. Shells were also used as decoration for pottery.

In Native American trade and commerce, mollusks played an important role. Wampum made of polished shells and parts of shells were used as a type of money. Unstrung beads of wampum were traded and exchanged for material goods.

Polished shell beads were also worn as decoration and also signified rank in the tribe. Quite often beads were woven into belts or strung together on strings.

Mollusks also served as a form of communication between tribes. Official messages were often accompanied by a belt woven from mollusk beads that served as a symbolic representation of the message.

Because mollusk shells are made of calcium compounds, they are often preserved for hundreds of years. This has enabled archaeologists, historians, and Native Americans to learn a great deal about previous cultures. This in turn has enabled contemporary Native Americans to continue the customs of their ancestors.

Many Native American tribes wore ornaments made from shells or pearls.

Those Amazing Mollusks!

The word mollusk comes from the Latin *molluscus,* meaning soft. This phylum of animals is soft-bodied and has either a shell inside or outside their bodies. Mollusks that you may be familiar with include the clam, oyster, snail, slug, octopus, and squid. Next to arthropods, the mollusk is the largest phylum of animals with over 100,000 species.

There are many interesting and strange types of mollusks. For example, giant squid are the largest of all invertebrates. They can weigh up to 2000 kilograms (4400 pounds) and be over 20 meters (over 60 feet) in length.

Mollusks vary greatly in their shape, size, and general appearance. Most have some type of shell. The shell may be on the outside of the body, as in a clam. Or the shell may be inside the body, as in a squid. The shell is usually made of a material called calcium carbonate. Calcium carbonate is similar to concrete. It is made by a part of the body called the mantle. Some animals produce large thick shells. For example, the shell of the giant clam can be over a meter (several feet) wide and weigh over 200 kilograms (400 pounds).

Fun Facts:
Mollusks range greatly in size. Some tiny clams are less than one millimeter long (0.04 inch). Giant squid can reach 30 meters (about 100 feet).

There are three main classes of mollusks. Bivalves are animals with two shells. You have probably seen a clam, mussel, oyster, or scallop. These animals cannot move quickly and usually filter water through their bodies to capture food particles.

Gastropods are animals that have a single shell, such as snails. The mouth is usually equipped with a rasplike tongue called a radula; this is also found in other mollusks. Generally used in scraping up food, the radula may be considerably modified. Some species can inflict a dangerous wound with their radula. In oyster drills, the radula can bore through a shell.

Cephalopods are usually predators that have tentacles. Squid, octopus, cuttlefish, and the nautilus are examples. These animals have eyes and sucker-bearing tentacles that they use to capture prey, such as fish.

Mollusks also contain soft tissue referred to as the visceral mass. The mantle, stomach, heart, and gills make up the visceral mass. Univalves and bivalves contain a muscular foot which they use for movement, burrowing, or attachment.

Mollusks are quite advanced in that they have a well developed nervous system. A brain collects sensory information from systems of nerves. Mollusks also have circulatory systems in which a heart sends blood to the body. Many also possess kidneys and other complex organs.

Although vision is poor in most mollusks, cephalopods, such as squid, have eyes with lenses, retinas, and other features remarkably like those of vertebrates. Some gastropods have well-developed senses of smell and can locate food in the water at a considerable distance.

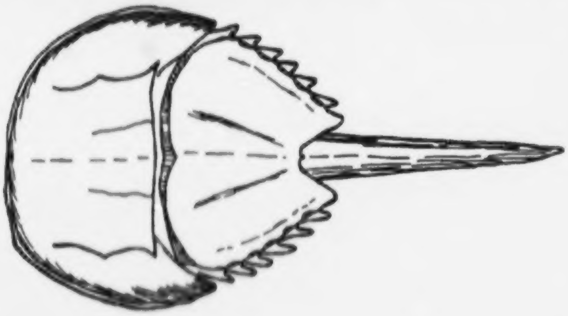
Reproduction is sexual. The basic mollusk pattern is to have separate sexes, with sperm and eggs sent into the water, where fertilization and early development occur.

Most mollusks have a larval stage in which the larvae swim before they settle on the bottom. Some oysters are remarkable in caring for the young inside the mantle cavity and switching back and forth from being males to being females.

What is a Mollusk?

Directions: Use textbooks, encyclopedias, and other science books to fill in the specific characteristics of Mollusks.

Characteristic	Mollusk Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	



Horseshoe crabs are an ancient species more closely related to spiders than true crabs.

THE
ARTHROPODS

This Unit Includes

I. For the Teacher:

- **Teacher Information**
  - *Unit Overview*
  - *Lecture Notes*
- **Teacher-Directed Activity**
  - *Investigation: Spinning a Web*
  - *Investigation: Arthropod Filter*

II. For the Student:

- **Student Information**
  - *Cultural Connections: Cajun Crustaceans*
  - *Those Amazing Arthropods!*
  - *Crustaceans, Arachnids, and Insects*
- **Student Activity**
  - *Ant Attractors*
  - *Arthropod Treasure Hunt*
  - *Arthropod Anatomy*
  - *What is an Arthropod?*

Unit Overview

Organism Highlights

Arthropods are the most abundant organisms on Earth. Over 90% of all animals are arthropods. They are extremely successful at adapting to a variety of environments and are found at every corner of the globe. This unit helps students understand why this group of animals is so successful and highlights some of the most interesting features of this extraordinary group of animals.

Suggested Pacing Chart

Day 1:

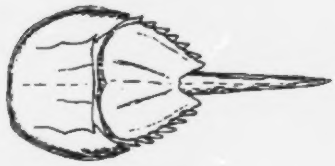
1. Give a lesson/lecture on the arthropods. Lecture notes are provided on page 54 if you choose to use them.
2. Students should read Student Information, *Those Amazing Arthropods!*, on page 59 or the Blackline Master.
3. For homework, students should define the terms at the end of the reading. You should also assign the extended homework assignment titled *What is an Arthropod?*, on page 64 or the Blackline Master.

Day 2:

1. Students should complete the Teacher-Directed Activity, *Investigation: Spinning a Web,* on page 55-56. You will need to gather together some of the materials necessary to do this activity ahead of time.
2. For homework, students can write up the investigation into a formal report.

Day 3:

1. Students should complete the Teacher-Directed Activity, *Investigation: Arthropod Filter,* on page 57. You will need to gather materials for this investigation ahead of time.
2. For homework or in-class work, students should read *Cultural Connections: Cajun Crustaceans* on page 58 or the Blackline Master.



Chemicals from the blood of horseshoe crabs are used to help manufacture drugs.

Day 4:

1. Students should conduct Student Activity, *Ant Attractors*, on page 61 or the Blackline Master.
2. Students should also read *Crustaceans, Arachnids, and Insects!* on page 60 or the Blackline Master.

Day 5:

1. Students should complete the Student Activity, *Arthropod Anatomy* on page 63 or the Blackline Master. You will need to buy some arthropods, such as crabs, crayfish, or lobsters, to do this activity.
2. Closure should also be brought to the unit by discussing the results of the Student Activity, *Arthropod Treasure Hunt,* on page 62 or the Blackline Master.

Links to National Science Education Standards:

1. Science As Inquiry

"Students should develop general abilities, such as systematic observations, making accurate measurements, and identifying and controlling variables." Design and Conduct a Scientific Investigation, Grade 5-8.

2. Science and Technology

"Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation." Communicate the Process of Technological Design, Grade 5-8.

3. Life Science

"Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unit

among organisms becomes apparent from an analysis of internal structures and chemical processes." Diversity and Adaptations of Organisms, Grade 5-8

Interdisciplinary Connections:

Language Arts

There are a number of very interesting books for students that focus either directly or indirectly on arthropods. One book titled *Beautiful Swimmers,* by William Warner, provides an in-depth account of the natural history and commercial implications of the blue crab in the Chesapeake Bay. Perhaps your students would enjoy reading this book.

Mathematics

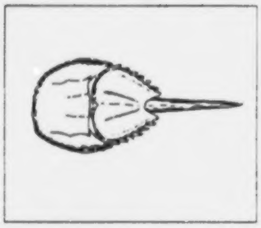
There are a couple of exercises in this unit which have math applications. The lesson titled *Arthropod Treasure Hunt* provides data that can be graphed and analyzed by students. A class graph can also be made from averaged class data. For geometry teachers, an interesting exercise would be to measure the angles in the spiders' webs that students capture. The variability or consistency of angles would be an interesting variable to measure.

Social Studies

There is probably no other single animal that has had a greater influence on human civilization, particularly in the tropics, than the mosquito. Malaria-ridden mosquitoes are responsible for the deaths of millions throughout the world. In fact, malaria is still a major health problem in many parts of the world today. It would be interesting to study the effect malaria has had on different civilizations through time as well as its current status in the world.

Surfing the Web:

1. http://www.calpoly.edu:8010/cgi-bin/db/db/marine-biology/:/templates/index
This website provides a great introduction to marine arthropods.



2. http://insects.ummz.lsa.umich.edu
Sponsored by the Young Entomologists Society, students can learn how to become involved in this group and also learn about club activities and basic insect information.

3. http://www.bishop.hawaii.org/bishop/ento/ento.html
This homepage from Hawaii has images, current data, and links to specific types of Hawaiian arthropods.

4. http://www.fi.edu/tfi/hotlists/insects.html
This website provides great links to all kinds of insect-related websites, such as ants, beekeeping and cockroach facts.

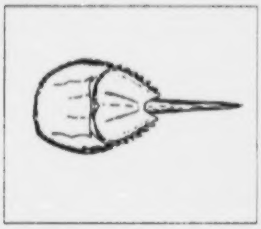
Assessment:

Student comprehension of various terms discussed in the reading and exercises can be assessed by students writing a one- to two-page report on an arthropod of their choice. Their report should use the terms discussed in the unit to describe the animal. Labeled diagrams should also accompany the report.

Resources:

Buschsbaum, Ralph. *Animals Without Backbones*, Univ. of Chicago Press, Chicago, 1972.
Levi, Herbert W. *Spiders and Their Kin, A Golden Guide*, Golden Press, New York, 1990.
Durrrell, Gerald, *The Amateur Naturalist*, Knopf, New York, 1983.
Video - *Animals Without Backbones: The Invertebrate Story*. United Learning. Niles, IL. 1-800-424-0362.
Warner, William, *Beautiful Swimmers: Watermen, Crabs, and the Chesapeake Bay*. Penguin Books, New York, 1977.

Lecture Notes



I. Background on Arthropods (means jointed foot)
  - A. Most abundant animals on Earth.
    - a. 850,000 species have been classified.
    - b. Perhaps another ten million have yet to be classified, or perhaps even one billion.
  - B. Arthropods are considered to be extremely successful at occupying every imaginable niche.
  - C. Main classes include arachnids, crustaceans, myriapods, and insects.

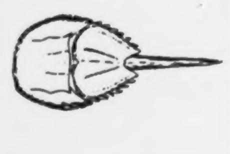
II. General Characteristics of Arthropods
  - A. Three main characteristics common to arthropods.
    - 1. Exoskeleton
      - a. Skeleton is on outside of body instead of inside, like ours.
      - b. Usually made of chitin - a material similar to our fingernails.
      - c. Is light and durable.
      - d. Prevents the body from drying out and protects internal organs.
      - e. Molting - process by which exoskeleton is shed and new one is formed.
    - 2. Segmented Body
      - a. Usually two or three body segments.
      - b. Segments in many arthropods are designed to bend.
    - 3. Jointed Appendages
      - a. Word "arthropod" means "jointed foot."
      - b. Usually have several pairs of jointed legs.
      - c. Many also have claws, fangs, pincers, and jaws.

  - B. Circulatory System
    - 1. Open circulatory system in which blood is pumped throughout body.
    - 2. Do not have blood vessels or tubes.
  - C. Respiratory System
    - 1. Blood does not carry oxygen; oxygen is obtained through book lungs and air tubes.
  - D. Nervous System
    - 1. Have an abundance of sensory organs, including well-developed eyes and antennae.
    - 2. Many are extremely well coordinated and capable of great speeds.

III. Arachnids
  - A. Examples include ticks, mites, scorpions, spiders, tarantulas, and horseshoe crabs.
  - B. Generally have eight legs and two main body segments.
  - C. Many spin webs to capture prey, and some are very poisonous (i.e. black widow spider).
  - D. No antennae

IV. Crustaceans
  - A. Examples include crabs, shrimp, barnacles, and lobsters.
  - B. Possess three body segments and appendages are attached to each segment.
  - C. Capable of regenerating appendages, such as claws.

V. Insects
  - A. Examples include: flies, wasps, butterflies, beetles, and ants.
  - B. Most easily recognized by three pairs of legs, and three body regions (head, throax, abdomen).
  - C. Extremely successful group - many have complex social organizations (i.e. bees and ants).



Investigation: Spinning a Web

Objective:

Students will investigate the complexity of spider webs by collecting them and attempting to create a web of their own.

Materials:

- White poster board
- White glue
- Paper cups
- Paint brushes
- Spray paint
- Yarn or thread
- Cardboard (thick) or Styrofoam sheets
- Pins or toothpicks

Spiders are helpful arachnids. They eat huge numbers of harmful insects.

Background:

Arachnids are one of nature's truly amazing creatures. The most familiar and common arachnids, spiders, have the remarkable ability to spin webs. The primary purpose of a web is to capture prey that flies or crawls into its tangle. The spider then kills the prey by biting it, or waits for it to die. Often spiders will wrap the prey in additional silk and eat it at a later time. If you have ever studied a spider web closely, you know that it is incredibly symmetrical, in fact flawless. These animals have an innate ability to create webs, which is very difficult for humans to duplicate. This exercise asks students to study spider webs, developing an appreciation for their complexity by attempting to copy the work of a spider and creating their own webs.

Fun Facts:

In many cases, the female spider eats the male once fertilization is complete.

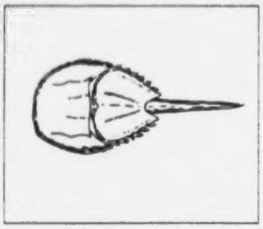
Procedure:

1. Begin the lesson by asking students if they have ever seen a complete spider web and then to describe it. Solicit a volunteer from the class to draw a spider web on the chalkboard. While the student is doing this, have other students draw individual webs at their seats.

2. After students have completed their drawings, ask them how spiders go about producing and spinning a web. Describe how spiders have specific structures, called spinnerets, on their bodies that produce "silk."

3. Tell students that you have gathered materials that they will use outside to capture a spider web. If you do not want to take the entire class outside for this part of the investigation, you can collect the webs yourself over the weekend or after school. If you prefer to take photographs of webs, that will work well, too.

4. Provide each student group with a 12" x 12" piece of white poster board, a small paper cup with a mixture of 50% glue and 50% water, a can of spray paint (a can for every 8-10 students is sufficient). Instruct students that they will go outside in search of spider webs. It is very



important to tell students that they are not to harm the spiders. Spiders should be gently coaxed away from their webs before the webs are preserved.

5. Once students have found a web and coaxed the spider away, they should spray the web with spray paint.

6. Next they must quickly paint their poster board with glue.

7. Quickly, before the glue has dried, they should wave the vertical posterboard flatly and slowly through the web. The web should stick against the poster board, and preserve its original form. If this is done correctly, you should have some beautiful webs.

8. Take the webs back to the classroom. Compare the webs and discuss the differences. Hopefully, students will be impressed by the complexity and beauty of the webs.

9. If they are not impressed, challenge them to make a web as symmetrical and neat as those they have collected. To do this, they will need thread or yarn, straight pins or toothpicks, and thick cardboard or Styrofoam.

10. Using the pins or toothpicks as anchor posts stuck into the cardboard or Styrofoam, students should begin weaving their webs by wrapping the yarn or thread around them.

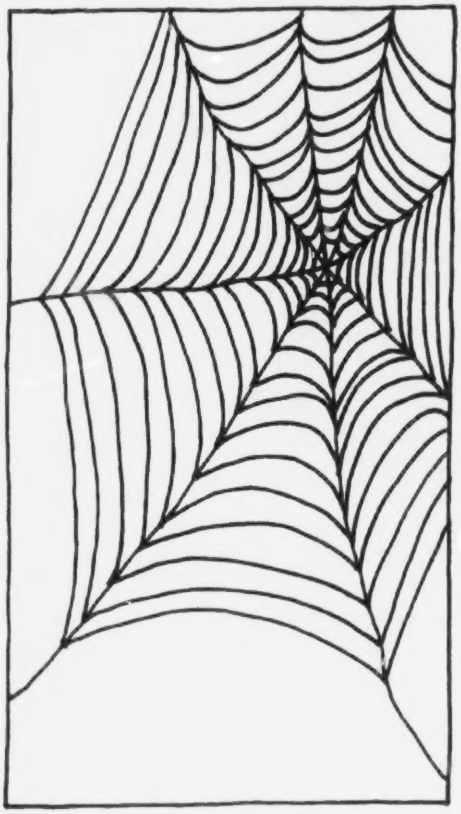
11. It will take 30 to 60 minutes for students to complete their webs. It is likely that you will have some very well-done webs, but few will match the artistry of spiders.

Assessment

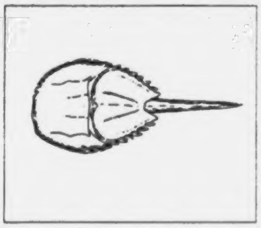
The natural spider webs, as well as student-made webs, can serve as assessment pieces accompanied by an explanation of how both were constructed. Students should write a paragraph of why it is easier for a spider than for humans to make a web.

Conclusion

Discuss with students why they think spiders are better web spinners than people. Explain that scientists are not quite sure how spiders are able to spin such perfect webs. They are not taught this craft by their parents, but they remarkably know how to do it at a very young age. Challenge students to think of other extraordinary activities that arthropods can perform (i.e. bees making honey in a hive, butterflies migrating great distances, and ants making large anthills).



Investigation: Arthropod Filter



Objective:

Students will explore the life in the top layer of soil by creating a filter. They will learn about the great abundance of life found in the soil which often is overlooked.

Materials:

- Plastic soda bottle
- Jar or beaker
- Magnifying glass
- Trowel or small shovel
- Ruler
- Light source

Background:

There are thousands of arthropods which often go unnoticed because they live in places that are out of sight. One such place is in the ground. The top layer of soil is home to scores of organisms, including bacteria, fungi, algae, roundworms, earthworms, insects, and numerous arthropods. These animals can be coaxed out of the soil with a small amount of heat generated from a light bulb. They can then be identified and studied.

Fun Facts:

There may be as many as 300 million insects for every person on the earth!

Procedure:

1. Begin the lesson by asking students if they think many things live in the ground. Most likely they will respond by saying no. Tell them that, surprisingly, the soil has a lot of life in it.

2. Provide each student group with a plastic soda bottle. Instruct them to carefully cut off the top third of the bottle. This will serve as a container and funnel.

3. Next, give each student group a ruler and small shovel. Go outside to an area where you can dig some soil.

Have students measure out a 10 cm. x 10 cm. square. They should dig the dirt, leaves, and twigs down about 7 cm. and place the soil in their containers.

4. Bring the containers inside and place them in a jar or beaker with the mouth pointing down.

5. Place the apparatus under a light source and turn on the light. Place the bulb about 10-15 cm. from the soil. Let the apparatus stand a few hours or overnight. **Make sure the soil is not getting too hot, which could result in a fire.**

6. After a period of time, check for creatures that have come out of the soil into the container.

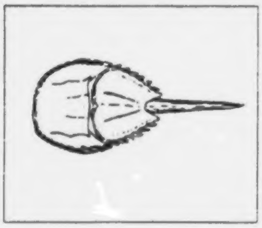
7. Attempt to identify the animals. Make a chart to record the phylums and species of the animals that come from the soil. Sketch the animals and label them.

Assessment:

This lesson provides a perfect opportunity for students to start an arthropod portfolio complete with species lists and diagrams. Students can continue work on their portfolios outside of school.

Conclusion:

Discuss the findings with your students. Ask them what role the light source played. Discuss why some organisms were found and others were not. Ask them why some students found different organisms than others.



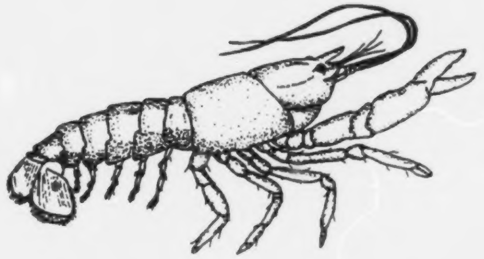
Cultural Connections: Cajun Crustaceans

Cajuns are the descendants of exiles from the French colony of Acadia, which is present-day Nova Scotia, Canada, and its surrounding areas. These people left their homeland in 1755 and found refuge in southern Louisiana a decade later. By 1790, about 4,000 Acadians occupied the wetlands along Bayou Lafourche and Bayou Teche. They later also settled in the Louisiana prairies. In the fertile bayous, they fished, trapped the fur-bearing animals, gathered moss, and raised sugar cane, cotton and corn. They intermixed with other ethnic groups: French, Spanish, German and Anglo-American settlers. In addition, they borrowed much of their culture from their black Creole neighbors.

The French-speaking Roman Catholic Cajuns today are estimated to number about 500,000 people. They have been able to maintain many cultural traditions of their ancestors. Their speech is an archaic form of French whose words are taken from the English, German, Spanish and Indian languages.

With the decline of muskrat in the wetlands of Louisiana, the nutria, another furry animal imported from Argentina has become the Cajun trappers' staple. Oystering and shrimping are increasingly important industries.

Cajuns have developed a unique style of cooking. They particularly specialize in the preparation of seafood because many Cajuns make their livings from the sea. Cajuns traditionally eat a crustacean called crayfish or crawfish. A Cajun crayfish recipe is included here. You and your family may want to try this recipe out at home and see what you think of Cajun cooking!



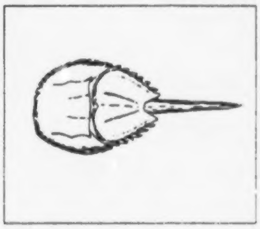
Crayfish are prized as food in many parts of the world.

Crawfish Etoufee

2 pounds crawfish tails
1/4 pound butter
1 cup chopped onion
1/2 cup chopped green pepper
1/2 cup chopped celery
2 tablespoons crawfish fat
2 cups cold water
1 tablespoon corn starch
1/4 cup chopped green onion
1/4 cup chopped fresh parsley
Creole seasonings to taste
salt
pinch dried thyme
pinch dried oregano
1 bay leaf

Season the crawfish tails with salt, plus a little black pepper and cayenne pepper. Heat the butter in a saute pan and add onions, bell pepper, and celery. Cook until translucent — about 5 minutes. Add crawfish fat (or substitute with extra butter), plus one-and-a-half cups water. Add Creole seasonings, thyme, oregano, bay leaf and crawfish tails. Bring to a boil, then reduce heat to low and simmer for 30 minutes. Dissolve the cornstarch in the remain-ing 1/2 cup water and add to the mixture. Add the green onions, parsley, and cook an additional 5 minutes.

Those Amazing Arthropods!



Have you ever been surrounded by a cloud of biting mosquitoes or bees? If you have, you may have wondered where all these pesky animals came from. They are part of the most abundant phylum on Earth: the arthropods. There are 850,000 known species of arthropods, with perhaps another 10 million yet to be discovered!

There are many different types of arthropods. Insects such as flies, beetles, and cockroaches are just a few examples. Spiders, tarantulas, and scorpions belong to another group called arachnids.

A third group called crustaceans include many tasty creatures such as lobsters, crabs, and shrimp. This is quite a wide range of animals that all belong in the same phylum. What is it that they have in common?

Arthropods have a hard outer shell called an exoskeleton. We have skeletons on the inside of our bodies, but arthropods have them on the outside. Most commonly, the exoskeleton is made of a material similar to our fingernails called chitin. Not only does the exoskeleton protect internal organs, but it prevents the arthropod's body from drying out.

Since the animal cannot breathe through its exoskeleton, special organs for breathing are necessary, such as tubes (tracheae) that deliver air directly to the body tissues. Because the exoskeleton does not increase in size as the animals grow, animals must shed their old exoskeleotn and grow a new one. This process is called molting. During this process, the animal is soft and vulnerable.

Another characteristic common to arthropods is jointed appendages. Our appendages include our arms and legs. They bend at joints. Arthropods have a wide variety of jointed appendages including wings, claws, pincers, and many legs.

Arthropods also have segmented bodies. This means that they have different divisions or segments along their bodies. For example, an insect has a head segment, an abdomen segment, and a thorax segment. Quite often these segments can bend where they join each other.

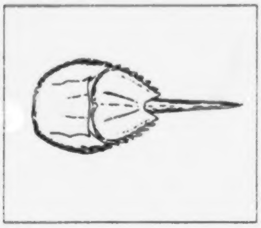
Arthropods have an open circulatory system. This means they do not have tubes or vessels that carry blood. Blood is pumped by a heart throughout open spaces in the body.

Arthropods have well-developed sensory organs. For example, the eyes of the common house fly have the amazing ability to see in almost all directions! Sensory organs include from one to many pairs of eyes and often antennae that serve as organs of touch and taste.

Arthropods reproduce sexually, with animals being either male or female. In most cases, eggs are fertilized inside the body of the female and then laid outside her body to develop further.

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

Open circulatory system
Exoskeleton
Molting
Segmented body
Chitin
Jointed appendages



Crustaceans, Arachnids, and Insects!

Next to insects, the crustaceans are the most abundant arthropod. They are the dominant form of animal life in the oceans. There are over 26,000 known species. You are probably most familiar with crustaceans such as crabs, crayfish, lobster, and shrimp. All these animals are great for eating!

While most crustaceans are small, they have a wide variety of body shapes and sizes. Mites can be smaller than the period at the end of this sentence, whereas lobsters can be over 60 centimeters (24 inches) long and spider crabs can span up to 3.6 meters (12 feet).

Like all arthropods, crustaceans have exoskeletons, segmented bodies, and jointed appendages. Most have a pair of jaws that they use for getting food and for protection. You may have been bitten by the claws of a crayfish or crab and know that they hurt! On the head is located a pair of eyes and a pair of antennae used for sensing the environment.

Another type of arthropod are arachnids. Scorpions, spiders, mites, ticks, and horseshoe crabs are all arachnids. Arachnids have eight legs and two body segments. Most arachnids are carnivores, meaning they eat meat or other animals. Many arachnids hunt or wait for small animals such as insects.

Their dependence on hunting has created many interesting body parts. For example, scorpions have stinging tails to paralyze prey. Spiders have a body part called a spinneret with which it weaves webs. Ticks have the ability to lodge themselves deep into the flesh to suck blood from their victims.

Generally speaking, arachnids are helpful animals because they eat harmful insects. However, some, like the black widow spiders and some species of scorpions, can be deadly.

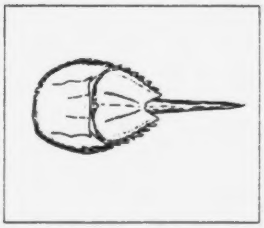
One of the most interesting common groups of all arthropods are the insects. Insects have bodies divided into three parts: head, chest, and abdomen. They are recognized by their six legs. Most insects have one or two pairs of wings. In some cases, the wings are very strong. The wings of a monarch butterfly carry it on its annual migration from as far north as Canada all the way to Mexico.

Like most arthropods, insects must shed or molt their exoskeletons as they grow. Some types of insects not only shed their skin, but totally change their appearance as they go through different stages. This is known as metamorphosis. Animals like butterflies, beetles, and bees go through four different stages. They start as eggs, which then hatch into larvae or caterpillars. The caterpillars then produce pupae or cocoons. After developing inside the cocoon, the adults emerge. They look like the insects with which we are familiar.

Perhaps what is most interesting about insects is their complex behavior. Ants and bees, for example, form complex communities, with each animal having a specific job and responsibility.

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

- Carnivores
- Metamorphosis
- Spinneret
- Larva
- Pupa



Ant Attractors

Suppose you are hired by a company that wants to sell chocolate-covered ants to candy stores. The first job in making chocolate-covered ants is to catch them. It is not an easy job to catch a lot of ants! Therefore, they hire you to figure out how to do it. Your task is to figure out what attracts ants best: the smell of certain things or different colors. Try to figure this out by doing the following:

1. Cut four 5 cm. x 5 cm. squares of the white, blue, red, and green colored paper.
2. On one square of each color do nothing and label the back of the paper "nothing."
2. On one square of each color place a mixture of 50% sugar and 50% water and label the back of the paper "sugar."
4. On one square of each color place a mixture of 50% salt and 50% water and label the back of the paper "salt."
5. On a square of each color place a mixture of 50% cola and 50% water and label the back of the paper "cola."

Place the square in an area that ants are known to live, such as a closet, outside, or in a garage. Wait a few hours and begin a stake-out for ants. Record your data in the following data table. Write in the number of ants at each type of bait.

Ant Attractors	White paper	Blue paper	Red paper	Green paper
Nothing				
Sugar				
Salt				
Cola				

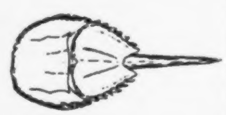
Once you are satisfied with your experiment, you need to decide what type of bait works best. Answer the following questions:

1. What combination of liquid and color attracted the most ants?

2. What can we assume has a greater influence on ant attraction: color or smell/taste or a combination?

3. What would be the ideal ant attractor and why?

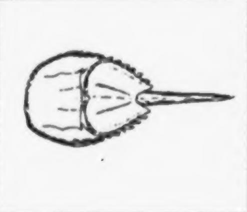
Arthropod Treasure Hunt



There are a lot more arthropods around you than you might think. Your school, home, yard, parks, and grocery store have lots of arthropods. In this activity you will try to find as many arthropods as you can. Record your observations in the following data table.

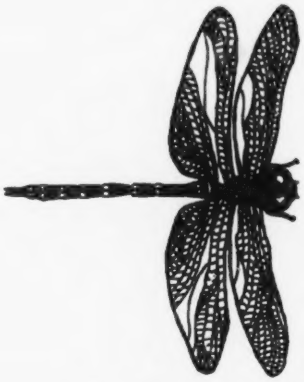
Organism	Location	Habitat

Once you have completed your chart, you will make a class list of all the different arthropods you have found. If you would like to know the exact species of the animals you have found, use different field guides to key out the animal. You may even want to keep a field notebook with drawings of the different animals you have found in your arthropod treasure hunt.



Arthropod Anatomy

Your teacher will provide you with an arthropod such as a crab, crayfish, shrimp, or insect. No matter what type of arthropod your teacher gives you, all types have many things in common. Before answering the questions, take a few minutes to look over your creature. Use a magnifying glass to look at some of its parts.



Dragonflies are among the most skillful airborne animals. Some have been timed flying faster than 35 miles per hour.

1. What type of arthropod do you have?

____

2. Is it crustacean, arachnid, or insect?

____

3. Give your reasons for classifying it in this group.

____

4. Feel its body and describe it. ____

5. How many appendages does your arthropod have? ______________________________

6. Describe what the appendages are and what they are used for. ______________________

____

7. How many segments does it have? ________ Describe their appearance and functions. _______

____

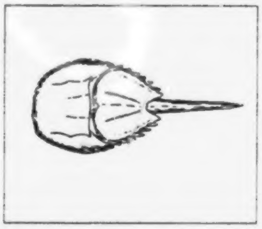
8. Describe how the top and bottom of the animal look differently, and state how these differences help the animal. ____

____

9. Take a close look at the head. List all the sensory organs it possesses. ________________

____

10. On the back of this page make a detailed diagram of your arthropod. Label the head, thorax, abdomen, eyes, antenna, mouth, appendages, anus, and any other structures you can identify.

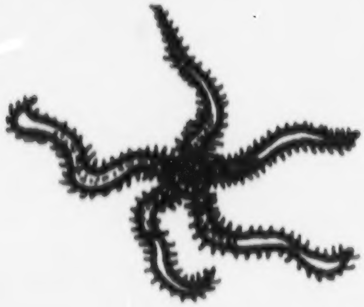


What is an Arthropod?

Directions: Use textbooks, encyclopedias, and other science books to fill in the specific characteristics of Arthropods.

Characteristic	Arthropod Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	

Brittle Stars are the most abundant of all echinoderms



THE ECHINODERMS

This Unit Includes

I. For the Teacher:

- **Teacher Information**
  - *Unit Overview*
  - *Lecture Notes*
- **Teacher-Directed Activity**
  - *Investigation: A Star is Born*

II. For the Student:

- **Student Information**
  - *Cultural Connections: Galapagos' Asian Delicacy*
  - *Those Amazing Echinoderms!*
- **Student Activity**
  - *Inside Out*
  - *What is an Echinoderm?*

Unit Overview

Organism Highlights

The echinoderms are a group of animals that your students have probably seen in its natural habitat at one time or another. Perhaps your students have seen starfish, sand dollars, or sea cucumbers on trips to the beach, or maybe in an aquarium. This unit explores the different types of echinoderms, focusing on ways their bodies are designed and function. Attention is also given to how they impact cultures.

Suggested Pacing Chart

Day 1:

1. Give a brief lesson/lecture on the Echinoderms. Lecture notes are provided on page 68 if you choose to use them.
2. Students should read the Student Information sheet, *Those Amazing Echinoderms!*, on page 71 or the Blackline Master.

Day 2:

1. Students should complete the Teacher-Directed Activity, *Investigation: A Star is Born*, on page 69. In order to do this activity, you will need 10-12 dried starfish. These can be obtained through a scientific supply company listed in the appendices of this Guide and at gift or shell shops.
2. For homework students should complete *What is an Echinoderm?* on page 73 or the Blackline Masters.

Day 3:

1. Students should complete the Student Activity, *Inside Out*, on page 72 or Blackline Master. You may want to order a starfish for dissection.
2. For homework or in-class work, students should read *Cultural Connections: Galapagos' Asian Delicacy* on page 70 or the Blackline Master.
3. Hold a class discussion about the problems in the Galapagos with sea cucumbers. Try to come up with some possible solutions.

Brittlestars can grow their arms back if they lose them.

Links to National Science Education Standards:

1. Life Science

"Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole." Structure and Function in Living Systems, Grade 5-8

2. Science in Personal and Social Perspectives

"Causes of environmental degradation and resource depletion vary from region to region and from country to country." Populations, Resources, and Environments, Grade 5-8

3. Science in Personal and Social Perspectives

"Human activities can induce hazards through resource acquisition, urban growth, land-use decision, and waste disposal. Such activities can accelerate many natural changes." Natural Hazards, Grade 5-8

4. Life Science
"Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive." Regulation and Behavior, Grade 5-8

Interdisciplinary Connections:

Language Arts
There are numerous references to invertebrates in literature. One of the most vivid descriptions of working with invertebrates comes from a book titled *The Log From the Sea of Cortez* by John Steinbeck. On an expedition to the Gulf of California with noted marine biologist Ed Ricketts, Steinbeck writes eloquently and with passion about the plethora of life seen on their journey.

While the book may be too lengthy for your students to read, you might consider reading excerpts aloud in class. One particularly interesting passage is in Chapter 8 in which he describes many of the invertebrates in the intertidal zone. Students can write their own *"Log From the .... "* describing life as they see it in their school, homes, or backyards.

Social Studies
One of the most serious environmental problems in the Pacific is occurring on the Great Barrier Reef in Australia. The culprit is the crown-of-thorns starfish which is devouring the reef. Students can practice geography by locating Australia and the outline of the Great Barrier Reef on a map. They can also use periodicals or the Internet to learn more about the problem, particularly its economic effect on tourism and fishing.

Surfing the Web:

1.http://www.mbl.edu/html/ MRC/specimens.html
Woods Hole Marine Biology Lab provides information on a variety of invertebrate phyla including Echinoderms. Included are beautiful images with detailed information about specific species.

2. http://www.mbayaq. org/
The Monterrey Bay Aquarium website provides information about one of the most spectacular aquariums in the world.

3. http://seaurchin.org/
This website is sponsored by the Sea Urchin Harvestors Association of California explains the sea urchin industry, world prices, and harvest records. Many images of sea urchins are also provided.

Assessment:

Students will gather numerous portfolio materials including diagrams from *Investigation: A Star Is Born* on page 69 and *Inside Out* on page 72. They will also create a summary grid of echinoderm characteristics titled *What Is an Echinoderm?* You may want students to add writing pieces to their portfolios as spin-offs from *Cultural Connections: Galapagos' Asian Delicacy*, page 70, and *Those Amazing Echinoderms!*, page 71.

Resources:

Buschsbaum, Ralph. *Animals Without Backbones*, University of Chicago Press, Chicago, 1972.
Carson, Rachel. *The Sea Around Us*, The New American Library, New York, 1950.
Coulombe, Deborah. *The Seaside Naturalist*, New Jersey, Prentice-Hall, Inc., 1984.
Steinbeck, John. *Log From the Sea of Cortez*, Penguin Books, New York, 1941.
Video - *Animals Without Backbones: The Invertebrate Story*. United Learning. Niles, IL. 1-800-424-0362.

Lecture Notes

I. Background on Echinoderms
- A. Echinoderm - from Latin meaning "spiny skin."
  - 1. Sea urchins have very spiny skin.
- B. Examples of echinoderms: starfish, sea urchins, sand dollars, sea biscuits, sea cucumbers, and crinoids.
- C. Live in marine environments.

II. General Body Characteristics
- A. Radial symmetry.
- B. Rays are arm-like structures radiating from a central point like spokes in a wheel.
- C. Colors: purple, red, brown, orange, and green.
- D. Calcium carbonate plates under skin.
- E. No head or brain - few specialized sensory organs.
- F. Nervous system consists of radial nerves from central disk.

III. Food-Getting
- A. Possess water vascular system.
  - 1. Use water to create pressure inside a series of tubes.
  - 2. Along rays are hundreds of small tube feet that have small suction cups at end.
    - a. Tube feet are located in ambulacral groove.
  - 3. Water pressure is controlled to increase or decrease suction.
  - 4. Suckers attach to objects for moving and obtaining food.
- B. Starfish prey on bivalve mollusks such as oysters, clams, and mussels.
  - 1. Use rays with tube feet to slowly pry open shell.
  - 2. Starfish may struggle for two or more days to open shell.
  - 3. Once shell is open, starfish ejects its stomach into shell.
    - a. Stomach secretes digestive juices into shell.
    - b. Draws nutrients into body through tube and absorbs tissues of its prey.

IV. Reproduction
- A. Sexual Reproduction.
  - 1. Fertilization of eggs occurs outside body.
  - 2. Males and females send sperm and eggs into water separately where they meet to form larvae.
  - 3. Female starfish releases as many as 2.5 million eggs.
- B. Asexual Reproduction.
  - 1. Regeneration - have ability to reproduce when cut in half.
  - 2. Oyster fishermen used to think they were eradicating starfish who were eating oysters by slicing starfish in half - but in fact they were actually creating more of a problem by increasing starfish numbers due the starfish's ability to regenerate.

Investigation: A Star Is Born

Objective:

This investigation familiarizes students with the basic external features of the starfish. Students will not only learn to identify the structures, but to state their functions.

Materials:

- One dry starfish per student group

Background:

Starfish are probably the most familiar representative of the echinoderms. There are over 1,600 species of the familiar sea stars which are in the class Asteroidea. While most species have five arms, the number varies greatly and can exceed 20. Long-armed species usually turn their stomachs inside out to digest prey, whereas short-armed species usually swallow their prey whole.

Procedure:

1. Provide students with a dried starfish. Instruct them to be careful when handling the echinoderms, because they can crack or break easily. Once they have taken a minute or two to study their echinoderms, they should answer the following questions. You may want to write the following tasks on the blackboard or overhead projector.
2. Tell students to rub their fingers along the surface of the animal. Describe how it feels.
3. Ask students how they think a live animal would feel compared to a dried one?
4. Have them describe the differences between the top (dorsal) surface and the bottom (ventral) surface.
5. Starfish have radial symmetry. Students should look at the starfish and describe why it has radial symmetry and not bilateral symmetry.
6. Tell students to look at the underside of the starfish. In the center is a small opening. What is the purpose of this opening?
7. Students should then study the groove on each arm. Look at the tiny knobs. These are tube feet. Have students describe what they look like and describe what they are used for.
8. Next have the class count the number of tube feet on a single arm. How many are there? How many are there on all five arms?
9. Students should then study the top surface. Directly in the center of the starfish is a small hole. This is the anus. Have students describe its function.
10. Just to the side of the anus is a slightly differently colored round spot. This is called the madreporite or sieve plate. Believe it or not, it has over 200 small pores. Students should describe their job.
11. On a separate piece of paper, students should make separate drawings of the top and bottom surfaces of the starfish. Have them label the central disk, anus, and madreporite on the top surface. They should label the tube feet, mouth, and arms (rays) on the bottom surface.

Assessment:

Students can create annotated diagrams of starfish with captions explaining the processes involved in preying upon a clam.

Conclusion:

Discuss how other echinoderms, such as sea urchins, sand dollars, and brittle stars, have different body modifications. Ask students, how are these body modifications useful in helping echinoderms survive?

Cultural Connections: Galapagos' Asian Delicacy

Sea cucumbers are highly prized delicacies in many East Asian cuisines. They are a high-quality food because their flesh contains 50 to 60 percent protein. Sea cucumbers are smoked, dried, roasted, and even eaten raw in some Asian countries. In the Galapagos Islands, there has been rampant over-fishing of sea cucumbers. The Galapagos sea cucumber population is now threatened by demand. They have become the focus of a debate pitting economics against the conservation of the unique Galapagos wildlife. The debate involves commercial interests, fishermen, government agencies, scientists, and conservationists.

Sea cucumbers play a vital role in ocean ecology. They turn over bottom sediments, exposing them to oxygen. This helps break down organic matter, freeing nutrients for plant and animal use, and creating habitat for smaller creatures. They also form an important link in ocean food chains. In the process of reproducing, sea cucumbers provide food for countless marine animals. But when over-fished, sea cucumbers' numbers can remain depressed for years. At low population levels, the chances of sea cucumber sperm and eggs meeting are greatly reduced.

The Galapagos archipelago comprises 13 major islands, six small islands, plus more than 40 islets. They sit along the equator in the Pacific Ocean about 600 miles off the coast of South America. Ecuador declared the islands a national park in 1959. The park protects almost 97 percent of the Galapagos, more than 5,000 square miles. Also, the government decreed a 43,000 square mile Galapagos Marine Resources Reserve for the surrounding waters in 1986.

Trouble started for the sea cucumbers when many poor Ecuadorians came to the Galapagos in the late 1980s and early 1990s. They found that they could make $100 a day there fishing for sea cucumbers, compared to $71 a month from the over-fished waters off Ecuador. Most sea cucumbers were captured for the lucrative Hong Kong market, and, as a result, too many sea cucumbers were taken.

Responding to concerns raised by scientists and traditional Galapagos fishermen, the Ecuadorian government halted fishing in the marine reserve in 1992. In 1993, the International Union of the Conservation of Nature issued a report which warned that the sea cucumber had already been eliminated from many areas around the Galapagos. Despite quotas on sea cucumber harvests, fishermen continued to catch the animals because there was little fear of law enforcement. An estimated 6 to 10 million were harvested in the fall of 1994 — over ten times the legal limit. In December, the government halted all sea cucumber fishing. The local fishermen were very upset about this action. The season has remained closed, yet some illegal fishing continues.

A possible long-term solution to the overfishing is to raise sea cucumbers in captivity, then seed the larvae into the ocean when they are ready to change into adults. This will not be an easy process, but is worth a try.

Those Amazing Echinoderms!

You have probably seen echinoderms at one time or another. This phylum includes starfish, brittle stars, sand dollars, sea urchins and sea cucumbers. The word "echinoderm" actually means "spiny skin." If you were to step on a sea urchin, you would certainly think it was spiny, as well as painful.

All of these animals live in the water, most in salt water. There are over 6,000 species of echinoderms. They are most easily recognized by their radial symmetry. Most also have tube feet with which they move and get their food.

Echinoderms, like the starfish, usually show a superficial five-part radial symmetry and generally are equipped with hollow tube feet. The tube feet are propelled by an internal hydraulic system that is inflated with seawater. This water pressure system is referred to as the water vascular system. It enables animals like starfish to exert tremendous force, enabling them to grasp and pry open clams and mussels. In some animals, like the sea urchin, tube feet are absent, but are replaced with long, sharp spines.

Most echinoderms have complete or incomplete skeletons made of calcium carbonate. In animals such as sand dollars, the white skeleton remains long after the animal dies. In other animals, like the sea cucumber, only small pieces of calcium carbonate support the body.

Generally speaking, echinoderms are slow-moving. Some types of echinoderms, such as starfish, move with their rays. Generally speaking, echinoderms have well developed digestive systems. A mouth usually is located on the underside of the animal. The animal has a large gut which can often be turned outside the body to digest prey.

The nervous and circulatory systems are quite simple. A brain is often absent. But animals like the starfish can sense light through eyespots located on the top surface.

Many echinoderms, like starfish, have separate sexes. Both sperm and eggs are released into the water separately. Fertilization occurs when the egg and sperm meet in water to form larvae. Sometimes a female starfish will protect as many as 2.5 million eggs.

Many starfish have the amazing ability to grow new body parts that have been damaged or removed. This process is called regeneration. Some can even produce entirely new organisms from pieces that have been severed.

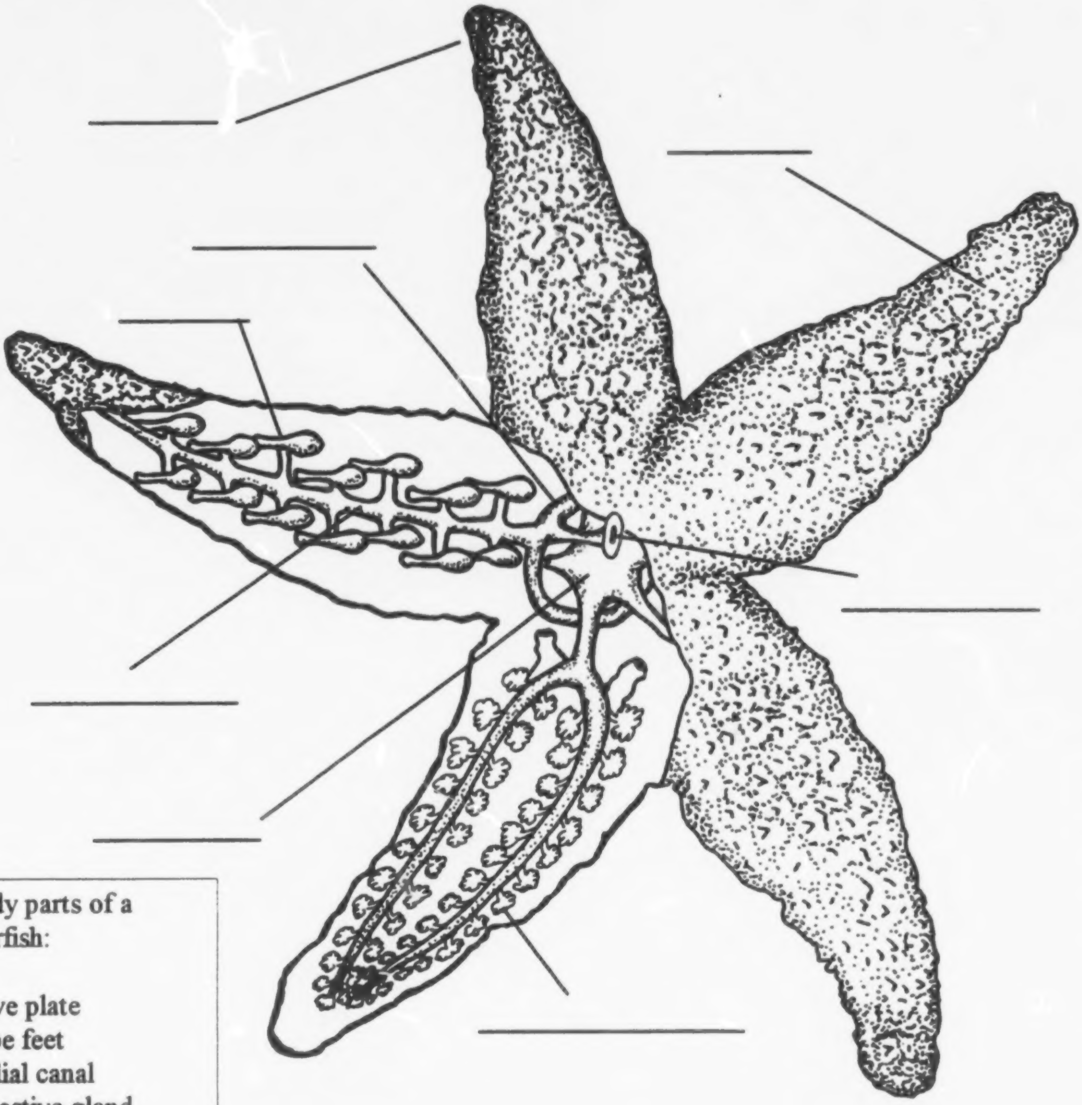
Echinoderms play a very important role in some ecosystems, eating a wide variety of plants and animals, and also serving as a food source. People also eat echinoderms. The internal organs of sea urchins and sea cucumbers are considered a delicacy in many parts of the world.

Below is a list of terms mentioned in this article. You can learn more about them at your school library:

Tube feet
Calcium carbonate
Regeneration
Eyespot
Radial symmetry
Water vascular system

Inside Out

Match the labels to the correct part of the starfish. After correctly matching the term to the body part, define the terms and state the function of the structure on the back of this paper.



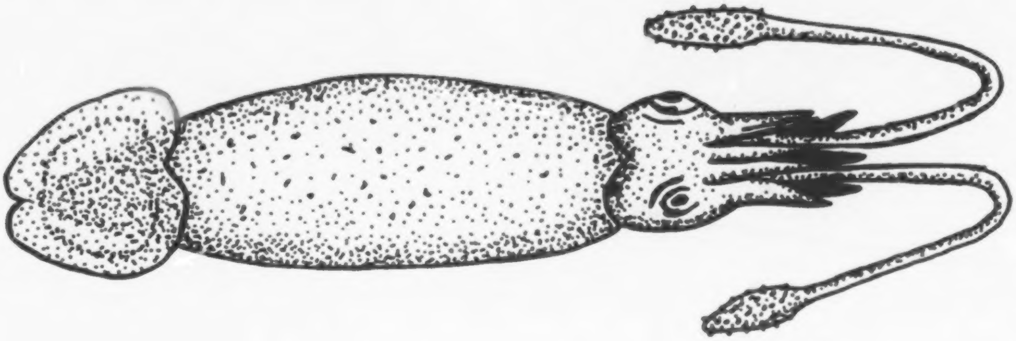
Body parts of a Starfish:

- Sieve plate
- Tube feet
- Radial canal
- Digestive gland
- Stomach
- Arm
- Ring canal
- Spine

What is an Echinoderm?

Directions: Use textbooks, encyclopedias, and other science books to fill in the specific characteristics of Echinoderms.

Characteristic	Echinoderm Characteristics
Symmetry	
Segmentation	
Body Cavity	
Nervous System	
Reproduction	
Digestion	
Circulatory System	
Muscular and Skeletal System	
Body Shape (sketch)	



THE APPENDICES

This Section Includes

I. For the Teacher:

- **Science Equipment Suppliers**
- **Video Script**
- **Answers to Student Activities**

II. For the Student:

- **Video Quiz 1**
- **Video Quiz 2**

Science Equipment Suppliers and Resources

1. **Carolina Biological Supply Co.**
   2700 York Road
   Burlington, NC 27215
   (Tel) 1-800-334-5551

2. **NASCO**
   P.O. Box 901
   Fort Atkinson, WI 53538-0901
   (Tel) 1-800-558-9595

3. **Delta Education, Inc.**
   P.O. Box 915
   Hudson, NH 03051-0915
   (Tel) 1-800-258-1302

4. **Connecticut Valley Biological Supply Co.**
   82 Valley Road
   Southampton, MA 01073
   (Tel) 1-800-628-7748

5. **United Learning, Inc.**
   (Curriculum-based educational videos; K-12)
   6633 Howard Street
   Niles, IL 60714-0718
   (Tel) 1-800-424-0362
   (Fax) 847-647-0918
   (Website) http://www.unitedlearning.com

6. **Videolabs, Inc.**
   (Makers of FlexCam, the video camera used in the show)
   5270 West 84th Street
   Minneaplolis, MN 55437
   (Tel) 1-800-467-7157

7. **VWR/Sargent-Welch Scientific Co.**
   911 Commerce Court
   Buffalo Grove, IL 60089
   (Tel) 1-800-SARGENT

8. **Leave Only Bubbles**
   P. O. Box 2397
   Key Largo, FL 33037
   1-800-890-0134

Name: ____________________

Video Quiz for Part 1 of
Animals Without Backbones: The Invertebrate Story

Directions: Mark the boxes on your answer sheet either "True" or "False." Or fill in the blank with the correct answer when you hear the "beep" tone.

T F

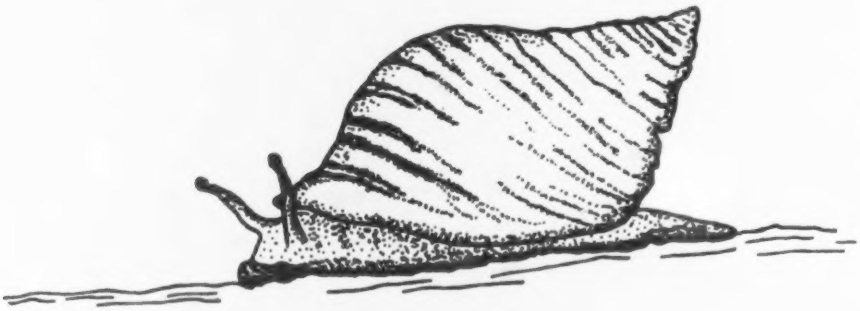
1. [ ] [ ] Most invertebrates do not have backbones.

2. [ ] [ ] Sponges are the most simply organized many-celled animals.

3. [ ] [ ] Anemone, jellyfish and other cnidarians take in food and get rid of wastes through the same body opening.

4. The three major worm groups are segmented worms, flatworms and ____________________ .

5. Clams, oysters, mussels, and other such two-shelled mollusks, are called ________________ .



Name: ____________________

Video Quiz for Part 2 of

Animals Without Backbones: The Invertebrate Story

Directions: Mark the boxes on your answer sheet either "True" or "False," or fill in the blank with the correct answer when you hear the tone.

T F

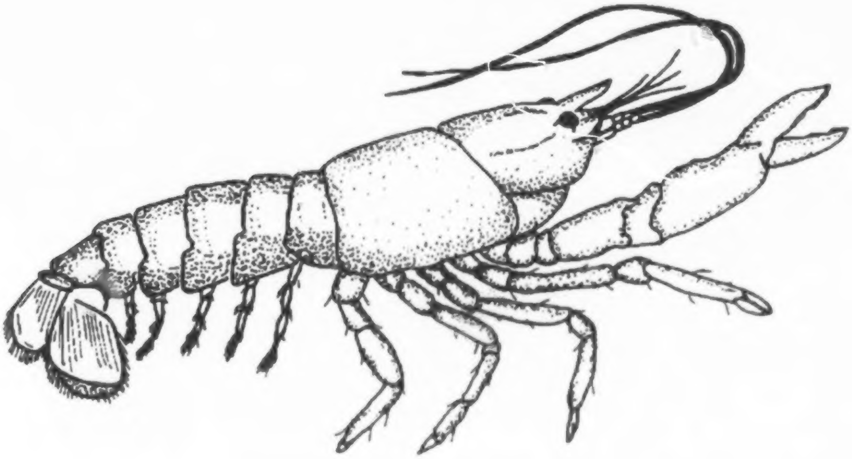
1. [ ] [ ] Seastars, and some other echinoderms, can regenerate lost arms.

2. [ ] [ ] Echinoderms pump air in and out of their tube feet.

3. [ ] [ ] There are more different kinds of echinoderms than there are kinds of arthropods.

4. All arthropods have a segmented body, jointed appendages and an ________________ .

5. All insects have three pairs of _______________ .



Animals Without Backbones: The Invertebrate Story

Part 1 (Viewing Time 22:30 with quiz)

They dart through the air, slide across the mud, scramble over the jungle floor, swim through the oceans, and can taste really great! They're the invertebrates – all those different animals without backbones with which we share the planet earth.

Hi, I'm Dr. Brian Jerome, and I'm standing in water that's home to this little guy – a leach – which is a kind of bloodsucking worm. He's just one of the many interesting creatures we'll meet while we take an expedition through the fascinating world of invertebrates.

We'll begin our exploration south of here, on the Florida coast. Famous for the great scuba diving they provide and a great place to fish, these waters are also home to many other kinds of interesting critters.

Invertebrates Defined
South Florida is a great place for studying invertebrates. It provides a good combination of both warmth and moisture that invertebrates need.

I've been out collecting today, and I'd like to show you some of the animals that I've found. Here's a sponge. I also found a very pretty sea cucumber, and here's a beautiful seastar. And I also found a sea urchin and a clam.

Now, all these animals look very different from each other, and you may be wondering what it is that makes them all invertebrates. Well, the fact of the matter is, it's what they don't have. None of these animals have a backbone. An invertebrate is an animal that doesn't have vertebrae, or a backbone.

On the other hand, humans have a backbone that you can see right here, and therefore, we're vertebrates, as are such familiar animals as reptiles, fish, and birds. All of these creatures do have backbones. But the fact is, we, and the world's other vertebrates, make up only a small – a very small – part of the animal kingdom.

Invertebrates—all those many different kinds of animals without backbones—are the real winners when it comes to numbers. The fact is over 90% of all the animals on the planet earth are invertebrates of one kind or the other. And it's this huge and fascinating group we'll be meeting today.

Porifera
The beautiful beach in the Florida Keys is where we'll begin our invertebrate expedition. It's a great place to look for all kinds of invertebrates that have been washed up by the waves.

And here's one that I'd like to show you. This is a sponge, which is in the phylum Porifera. It looks quite a bit different than the sponges you're used to, like this one which is a synthetic sponge that's made out of plastic, but this is a natural sponge. Natural sponges, such as these cleaned and washed ones ready for market, are very much in demand, and diving for them is big business in many of the world's warmer waters.

Once divers harvest the sponges from the ocean floor, they're trimmed and cleaned, and then hung up to dry and readied for shipment to market. Here's an old photo of a sponge diver from Florida's west coast. Sponges were big business for many years in Florida's thriving Greek immigrant community.

This small dried sponge is typical of most sponges in that it has a simple rounded shape. That means no matter which way we cut this sponge, each half mirrors, or looks like, the other half.

Sponges, such as this little fire sponge, are the most simply organized, or primitive, of all multicellular animals. They have no muscles, nerves or other organs or organ systems.

This is a typical sponge. Sponges are great natural filters. They have lots of tiny little holes called ostia that let water, along with oxygen and food, into the sponge. Water, along with waste produced by the sponge, then exits through this large hole called an osculum. This filtering system is so efficient that small basket sponges, like this one, can filter hundreds of gallons of water in a single week.

Cnideria

I'm in water that's home to members of the next phylum of invertebrates we'll explore. And here's one of its members—a jellyfish. Jellyfish are members of the phylum Cnidaria, as are such similar and interesting critters as flower-like sea anemones, corals, and sea combs.

Most cnidarians share several features. To start with, they're squishy, or soft bodied, being, as they are, composed mostly of water. More than ninety percent of a jellyfish's body is, for example, water.

Most cnidarians also share the same general body plan. The cnidarian body plan consists of a hollow sack with an opening at one end called the mouth. Cnidarians not only use the mouth to let food enter but to get rid of waste as well. Surrounding the mouth are arm-like structures often referred to as tentacles.

The cnidarian body plan consists of two cell layers. The outer layer is called the ectoderm, and the inner layer is called the endoderm. Between these two cell layers is a layer of jelly. And that's why so many cnidarians, like this one, are called "jellyfish."

Notice how the tentacles hang down from his body. I'm going to catch him so you can take a closer look. They're covered with stinging cells that paralyze any small animal that touches them. That's is how jellyfish and other cnidarians capture their food.

This sea anemone also has stinging cells on its tentacles. However, the fascinating little fish you see here have found a way around the danger. Called clownfish, they're not harmed stung by anemones. Nobody is sure why this is so— why anemones don't kill clownfish. But as you can see, the fish and their host anemones get along just fine.

When we hear the word "jellyfish" this is what we usually think of. What were looking at here is the jellyfish's medusa, or mature, free-floating, sexual stage. But there's also another side to the cnidarian life cycle.

And this diagram shows it. We'll begin when the sperm and egg join to form a larva. This larva then settles to the bottom to form an asexual stationary polyp. The polyp forms these saucer-shaped disks that are then released into the water. These disks then mature into the sexual form of the jellyfish that we saw earlier.

Well, as we've seen so far, the cnidarians are a pretty fascinating group of critters. I never get bored watching them. But of all their interesting characteristics, it's the amazing rock-building ability that some cnidarians possess which fascinates me the most.

Here, let me show you. This is a piece of brain coral that broke off the reef many years ago. And as as you can see, it's rock hard. That's because it contains the same calcium compound that's found in many rocks and the same one that make our bones hard. Yet, this rock-hard chunk of coral was made by tiny, jelly-soft cnidarians called stony corals.

And here are such rock-building coral. Notice the living coral polyps swaying back and forth in the current. Working together over many years, colonies of these tiny cnidarians can build huge reefs.

They do this by secreting calcium carbonate to form an exoskeleton of tiny rock-hard coral cups in which they live. Over time, the efforts of millions of these tiny little cnidarians can produce reefs that are hundreds of miles long.

Worms

This next group of animals is going to require some catching. So we're going fishing for worms – not with worms, but for worms.

I've put some meat into this little cage. Many worms love meat. The cage is to prevent fish from stealing our meat. So I'm going to throw this into the water. and come back in a little while to check on it after the worms have had a chance to find it

Well, we're back here to check on our bait, so why don't I reel it in and take a look and see what we've caught. Looks like we've got some. The worms are pretty small, so I'm going to take this bait and we'll take it back to the lab to take a look at some of the worms.

Well, our fishing expedition was a great success, and we landed a fine catch of worms. Now I'm going to take this FlexCam, which is a kind of video camera, and attach it to the microscope so we can take a closer look at our worms. And here's what they look like close-up.

Worms get their names from their shape. These are flatworms, and they belong to the phylum Platyhelminthes. That, as you may have guessed, means "flat worm." There are three main worm groups. We've already seen the flatworms, now we're going to take a look at the roundworms and the segmented worms.

And here are some tiny roundworms, or nematodes. Looking like tiny strands of spaghetti with pointed ends, roundworms make up the second major worm group.

And finally, here are some fine looking examples of our third major worm group that I just dug up. Notice how their bodies are divided into numerous rings, or segments. That's why they're called the segmented worms, or annelids. They're the last major worm group.

Now, I know worms aren't much to look at. But, as we'll soon see, worms, of one kind or another, have achieved some the animal kingdom's most impressive "firsts." Take sex for example. The whole notion of separate males and females— of having different sexes— that we humans take for granted, first appears among the roundworms.

But that's not all. Every time we take a bite, we owe a debt to worms. That's because the roundworms also developed nature's first efficient digestive system. To see how that's so, we'll use this pitcher to represent some of the invertebrates that we explored before we met the roundworms.

All these organisms have a "two-way" digestive system. That means they have a single opening both to let food in and to get rid of wastes. While this works, it is also very inefficient.

This bit of hose represents a roundworm. Roundworms are the first animals to develop a "one way" digestive system. That means that food enters at one end, through the mouth, and exits through the other end, the anus, as waste. This "one way" digestive system is much more efficient than the "two way" system found in less-developed invertebrates. And we see it first with the roundworms.

Finally, there's the matter of organs. As you know, our bodies, along with most complex animals, are full of complex organs, such as hearts, livers and kidneys. Such complex organs can't develop without three distinct cell layers. And that's something simpler organisms, such as sponges and jellyfish, don't have. All that changes, however, with these little creatures— the flatworms. Flatworms are the first group of animals with bodies that have three cell layers needed to produce the complex organs.

And while we're talking about organs, here's one of the most important ones any advanced animal can have—a heart. And, believe it or not, these animals, segmented worms, are the first animals in which true hearts appear. This earthworm has been specially prepared so we can see its hearts. They're the little red bumps you see and they pump the worm's blood through its circulatory system. They may not look like much. But it's hard to over-estimate what a giant leap forward having a heart is.

Now we're going to take a look at another worm. This is a tapeworm, which is a kind of flatworm. This particular tapeworm is common in dogs and that's where this one came from. Tapeworms illustrate another, and not so nice, side of the worm story. Some worms, such as this tapeworm, are dangerous parasites. Humans can become infected by eating under-cooked meat containing tapeworm larvae.

In those parts of the developing world where it's hard to maintain high levels of sanitation and water pollution is common, tapeworms and other kinds of parasitic worms are often a serious menace to public health.

Mollusks

Well, as you can see, we've moved into the woods to find our next invertebrate group, and here's one of them – a rare tree snail. This animal is native to south Florida, and is a mollusk, another important invertebrate phylum.

There are many different kinds of mollusks, but most of them, such as this little conch, are easy to recognize. All are soft bodied and most have a shell and a strong, muscular foot.

Some mollusks, such as certain snails and slugs, live on land. Others, such as this sea hare, a mollusk with an internal shell, spend all their lives in water.

Mollusks have been valued as food for untold centuries. In addition, mollusk shells have been used to make everything from jewelry, such as this beautiful African necklace, to tourist trinkets.

Clams on the grill taste great. Cooking them makes the tissue firmer so that it's easier to see. I'll use one of these to show you some of the body parts that are common to most mollusks. As you can see, the clam has a soft body that's surrounded by a hard outer shell. This is common to most mollusks.

Mollusks have three main body parts, and here's the first one. It's a tough, muscular foot. Clams use this to move around and to dig down into the mud in which they live. Next is the mantle. It's a membrane that covers most of the clam's body. As is the case with most mollusks, it contains glands that secret the shell. And here, under the mantle, is the clam's visceral mass. It contains the heart, digestive system and other organs. Together, these three main parts - the foot, the mantle and the visceral mass—make up the mollusk body plan.

Well, now that we know something about how their bodies are put together, let's go out into mollusk country and look at some of the most important kinds. Shallow bays, like as this one, provide great habitat for many different kinds of mollusks.

And even though there are thousands of different species of mollusks, we can divide them into three main groups. And the first group we're going to talk about are these— the bivalves. The bivalves include oysters, clams, mussels and other two-shelled mollusks. Each of the shells is called a "valve." The word "bi" means two, therefore bivalves are two-shelled mollusks.

Oysters, mussels, clams and other bivalves have been important sources of food for centuries. And today bivalves are still a valued food, and supplying them is an important business in many areas.

Remember the pretty little tree snail we saw earlier? It's a gastropod.

Gastropods are the second major group of mollusks we'll look at. Notice this critter's single shell. Gastropods, such as snails and this young conch, have either a single shell or, as is the case with this slug, no shell at all. While some gastropods, such as these snails, provide food, others cause serious crop damage that costs millions of dollars to control.

The last mollusk group we'll explore includes nautilus, octopus, and squid and their relatives. They're the cephalopods—the most highly evolved of all mollusks.

Ancient cephalopods, such as this fossil ammonite that thrived millions of years ago, had heavy shells. Today, with the exception of nautilus, cephalopods don't have an external shell.

Notice the arms at the front of this squid. All cephalopods have such arms surrounding their mouths. They use them for locomotion and to catch the crabs and fish they eat. Valued as food and as bait, cephalopods are also a vital link in natures's food chain, providing food for many commercially-important fish.

End of Part 1: Video Quiz Follows

Now we're going to take a short break from the show to ask you a few simple questions. They'll help to refresh your memory about some of the interesting animals that we've seen so far.

Just mark the boxes either "true" or "false," or fill in the blank with the correct word after you hear this tone. Good luck, and let's get started.

True or false. Most invertebrates do not have backbones.

True or false. Sponges are the most simply organized many-celled animals.

True or false. Anemone, jellyfish, and other cnidarians, take in food and get rid of wastes through the same body opening.

Now, answer the next two questions by ending the sentences with the correct words.

The three major worm groups are segmented worms, flatworms and ______.
And here's the last question.

Clams, oysters, mussels, and other such two-shelled mollusks, are called ______.

PART 2 (Viewing time: 13:25 with quiz)

Arthropods

Turn on a light and chances are you'll end up with bugs, especially here in the tropics. I'm using a lantern so I can collect some specimens. As you can see, I'm being pretty successful. Insects of all kinds are members of the Arthropoda—by far the largest of all the different animal phyla.

The arthropods also include such very different critters as millipedes, rock-covering barnacles, and spiny lobsters. All of them, as different as they look, are arthropods. There are, in fact, more different kinds of arthropods on the planet than any other kind of animal.

So far, scientists have discovered more than a million different kinds of arthropods. And they're still counting!

With so many different kinds of critters involved, what is it that lets scientists group them all together as arthropods? What, for example, do such different looking critters as these horseshoe crabs and this millipede have in common that makes them both arthropods? Well, as we're about to see, the answer involves three things.

I'm going to try and catch some shrimp so I can point out these three features to you.

It's a great time to catch shrimp. The tide is high and the moon is full, so let's see how I do. Looks like I got some. Let me get one out here.

Arthropods have a hard outer shell that we call an exoskeleton, and if you've ever eaten shrimp, you know that you have to peel off this shell before you eat them. The second thing that arthropods have is a segmented body. And here you can see the tail, which is quite large on a shrimp, which is one of the segments. And the third feature that arthropods have is jointed appendages.

And if you can look at the legs on this arthropod, you can see that they bend at the joints. Arthropods sometime have many jointed appendages, like antennas or claws. And these are the three features that all arthropods have, and it's what makes them arthropods.

Now that we know what it takes to be an arthropod, let's take a closer look into the matter of exoskeletons.

Take, for example, these busy little fiddler crabs. Not only do their exoskeletons support their bodies, their durable, tough shells also protect the fiddlers against predators, such as this hungry blue crab out hunting for a meal.

In addition, exoskeletons also help arthropods in yet another way. They're largely water-tight. And that helps to keep arthropods from drying out in the sun.

But as helpful as exoskeletons are to arthropods, they do cause a problem. They're hard, like a suit of armor.

And that means when arthropods, such as crabs, grow bigger, their old shells no longer fit. Fortunately, however, nature has found a way around this problem. It's called "molting," and crabs provide a great example of it.

Most of the time the crab's exoskeleton, or shell, is hard and rigid, but periodically the crab's body chemistry changes. And here's the result. This is called a "soft-shelled" crab. Notice how soft and flexible its exoskeleton is. While it's in this state, the crab replaces its old shell with a new and larger one. This new shell is soft to start, but it soon hardens just like the old one. It's by this ingenious process – molting – that arthropods grow bigger within their exoskeletons.

Scientists who study arthropods, such as this butterfly, divide them into a number of different groups. One of the most important of these groups contains such animals as crabs, barnacles and their relatives, pillbugs, and shrimp. All of them are members of the crustacia, one of the most important arthropod groups.

While there are many different kinds, it's pretty easy to tell if an animal is a crustacean. I'll show you how with a nifty little animal that lives under the rocks in streams like this one.

And here's a crawfish. Crawfish look like little lobsters, and where they live gives us a clue that they're crustacians. Most crustacians are water lovers. Than means they either live in or near water. In addition, crustacians also have a hard exoskeleton and two pairs of antennae.

Now that we've introduced the crustacians, let's move on to explore some other interesting arthropod groups.

And here's another important arthropod—a spider. Spiders are part of the class of arthropods called arachnids. There are many thousands of different spiders. All are great hunters.

This one is wrapping a bug trapped in its web in an escape-proof envelope of silk thread. The spider will then bite the bug and feed on its body juices.

Because they are such skillful hunters, spiders help us humans by eating huge numbers of harmful insects. Though there are many kinds, all spiders have the same basic body plan. First, they all have four pair, or eight legs. Here we see a spider using all hers to handle her catch.

Secondly, spiders' bodies ares made of two body parts – a cephalothorax, or combined head and chest, and an abdomen. These characteristics are shared by all spiders, and other arachnids, such as harvestmen, ticks, scorpions, mites and so-called horseshoe "crabs"—creatures from an ancient line more closely related to spiders than to true crabs.

But of all the many different arthropods, none fill a more important role than the insects. Found almost everywhere, the sheer number and variety of insects is staggering. Scientists have, in fact, counted more different kinds of insects than all other kinds of animals combined. There are so many insects around that it's estimated there are three hundred million of them on earth for every one of us humans.

With such a huge number and variety of creatures involved, how can one ever be sure just what is and what is not an insect? Well, as it turns out, it's easy. All you need to do is follow the "Rule of Threes." The number three is the key here. And I've brought along a model of a dragonfly to show you what I'm talking about.

Insect bodies are divided into three parts: a head, a chest or thorax, and an abdomen. They also have three pairs of legs. So, the next time you want to know if an animal is an insect or not, just remember the rule of threes: three body parts and three pairs of legs. If an animal has that, you know that it's an insect.

As you can imagine, with the arthropods being such a huge group with so many different kinds of critters, it's no surprise that we humans have a lot of contact with many of them. Sometimes that's good for us and sometimes it isn't. On the bad side of things, flies, mosquitos, and other such arthropods spread numerous deadly diseases.

And then there's farming. Some arthropods feed on the crops we grow, and that causes many farmers to use some very poisonous pesticides. Not only does this cost a lot, it can also poison the environment.

But, while it's true that some arthropods do cause us problems, there's also a good side to the arthropod story. Shrimp, lobsters and crabs, for example, are important foods. And bees, another very useful arthropod, help us by pollinating our flowers and crops, along with producing honey.

Still other arthropods help us in many different ways. "Ladybug" beetles and spiders, for example, help us by eating huge numbers of insect pests, while the horseshoe crabs we saw earlier yield chemicals that are important in the making of many useful drugs.

Echinoderms

The shore is a great place to explore. Poke around long enough and you're certain to discover some kind of fascinating critter. And here's one of them.

It's called a sea urchin. Sea urchins are echinoderms, and they're members of the next invertebrate phylum we'll explore. The word echinoderm means "prickly skin," and this urchin certainly has that.

Later, I found another interesting echinoderm. It's called a sea cucumber. Sea cucumbers may not look like much to us, but in many parts of the world they're a prized food. But of all the echinoderms, here's the one people are most familiar with – a seastar, or as it's sometime called, a starfish.

This one is a real beauty. Notice its five arms and how they radiate from a central point. That's a common body plan for many echinoderms. And turning the seastar over, we see rows of tube feet running along each arm. We wanted a better look at these tube feet, so we took the starfish back to our lab where we could use a FlexCam. It's a special video camera that lets us get a good close-up view of the tube feet.

And here they are running down the middle of the seastar's arm. By pumping water in and out of their tube feet, seastars can move along at a slow but steady crawl.

While I was snorkeling around here I found another seastar which I think is kind of interesting. As you can see, it has five arms.

But notice how this fifth one is shorter than the rest. That's because it had some kind of accident in which it lost this arm, but you can see it's starting to grow back. And that's called regeneration, which is a characteristic that's common to most echinoderms.

End of Part 2: Video Quiz Follows
Now let's take a few minutes to review some of the things that we've learned as we explored the fascinating world of arthropods and echinoderms.

The directions are the same as before.

All you need to do is check either "true" or "false," or fill in the blank with the correct word after you hear this tone.

Okay, let's get started.

True or false. Seastars and some other echinoderms can regenerate lost arms.

True or false. Echinoderms pump air in and out of their tube feet.

True or false. There are more different kinds of echinoderms than there are different kinds of arthropods.

Now here's a different kind of question. This time try to end the sentence with the correct word.

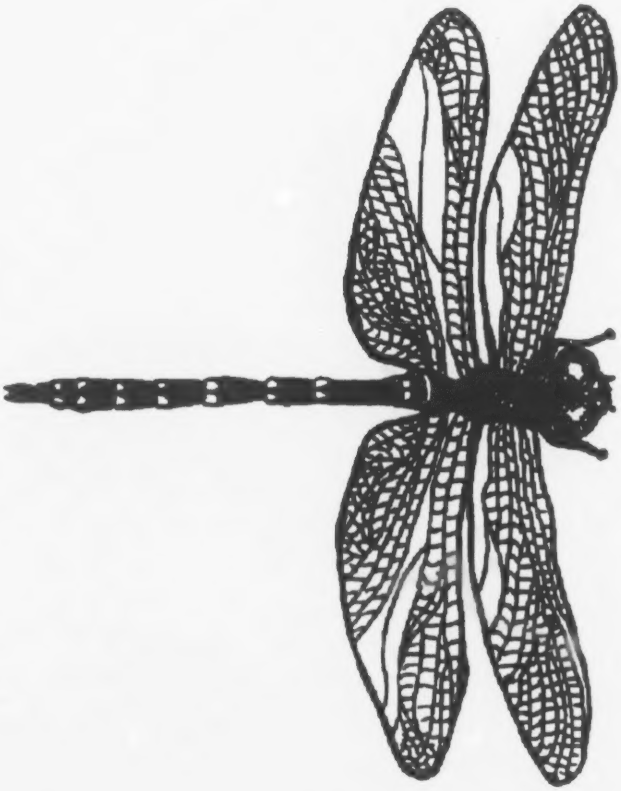
All arthropods have a segmented body, jointed appendages and an ______ .

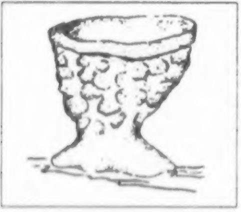
All insects have three pairs of ______ .

Well, that ends this quiz as well as our tour of the invertebrates— all those fascinating animals without backbones.

Answers to

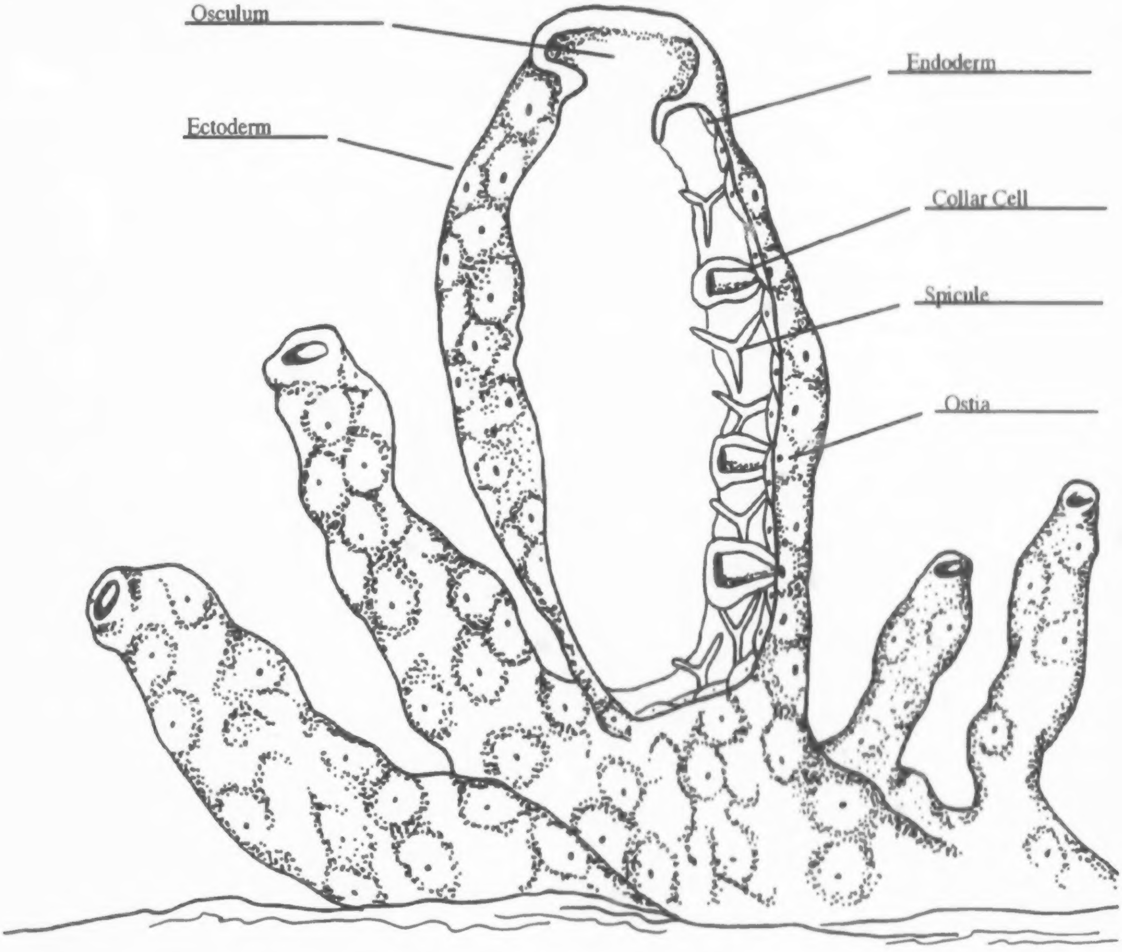
Student Activities





Name That Sponge

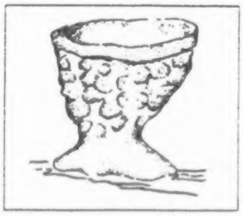
Using a biology book, a textbook, or an encyclopedia, fill in the correct parts of this sponge. Color the endoderm and ectoderm different colors. Also color the collar cells and spicules differently.

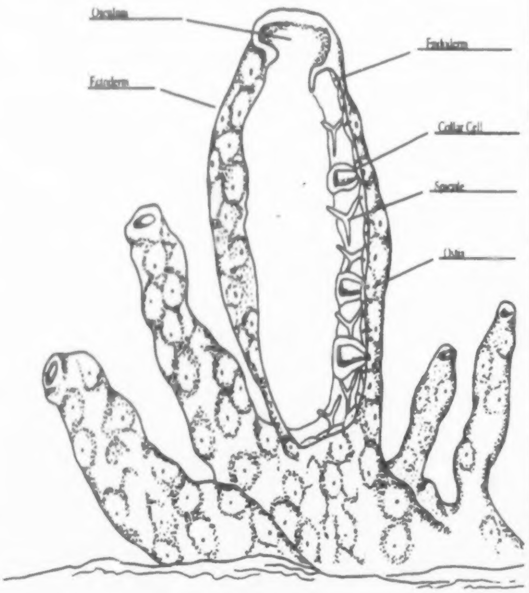


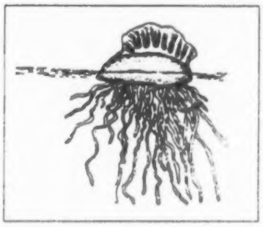
Provide the definition, state the function, and then place the term on the correct line on the diagram:

- Ostia
- Collar Cell
- Spicule
- Endoderm
- Osculum
- Ectoderm

What is a Porifera?



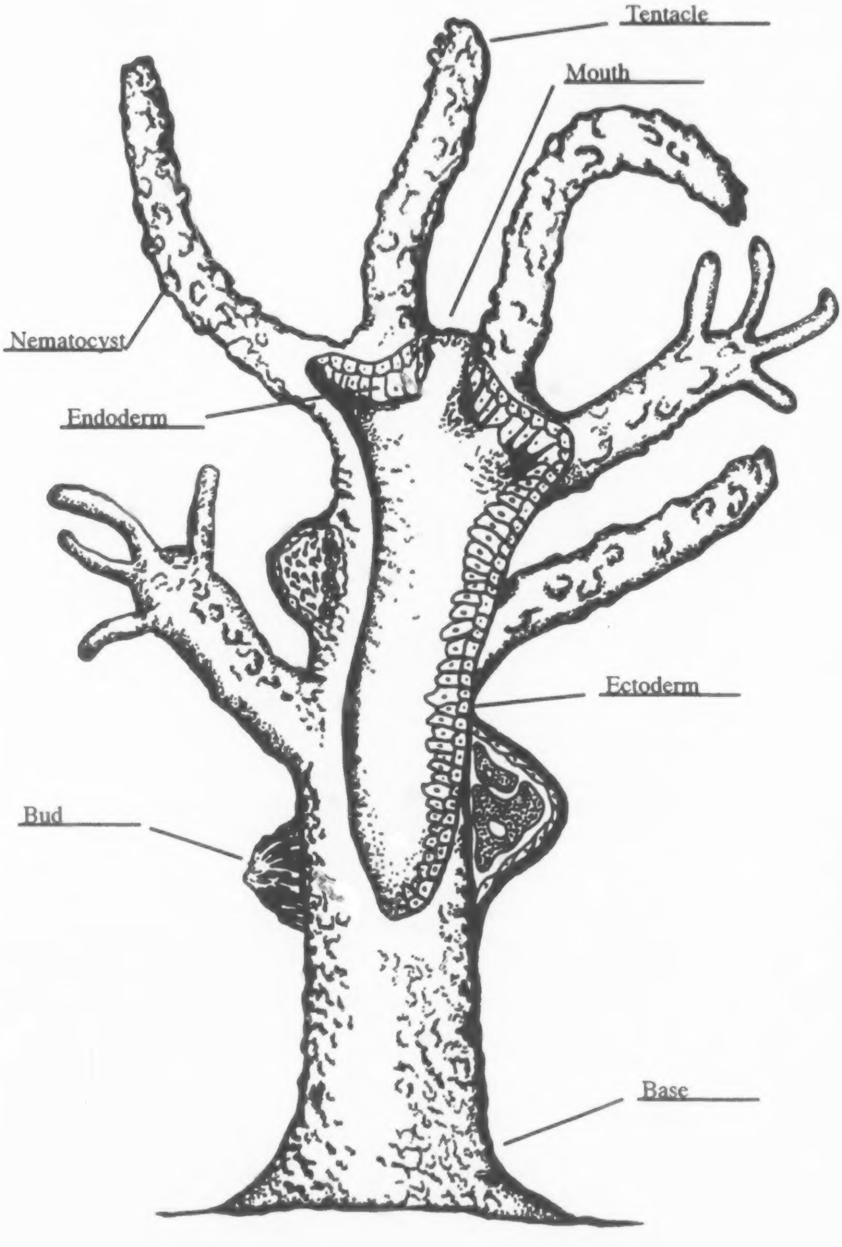
Characteristic	Porifera Characteristics
Symmetry	None or radial depending on species.
Segmentation	Absent
Nervous System	None
Reproduction	Asexual with buds or via regeneraton. Or sexually with larvae produced.
Digestive System	Filter feeders which use collar cells to capture and digest planktonic food.
Circulatory System	Canal System
Muscular and Skeletal System	No muscles. Skeletal system made of spicules and spongin.
Body Shape (sketch)	 Osculum Endoderm Ectoderm Collar Cell Spicule Ostia



Name That Cnidarian

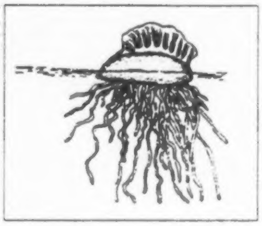
Using a biology book, a textbook, or an encyclopedia, fill in the correct parts of this hydra. Color the cell layers, tentacles, and mouth different colors. Be creative and sketch a prey item which the hydra is in the process of capturing with its tentacles.

Freshwater hydra are unusual cnidarians in that they do not have a medusa stage.



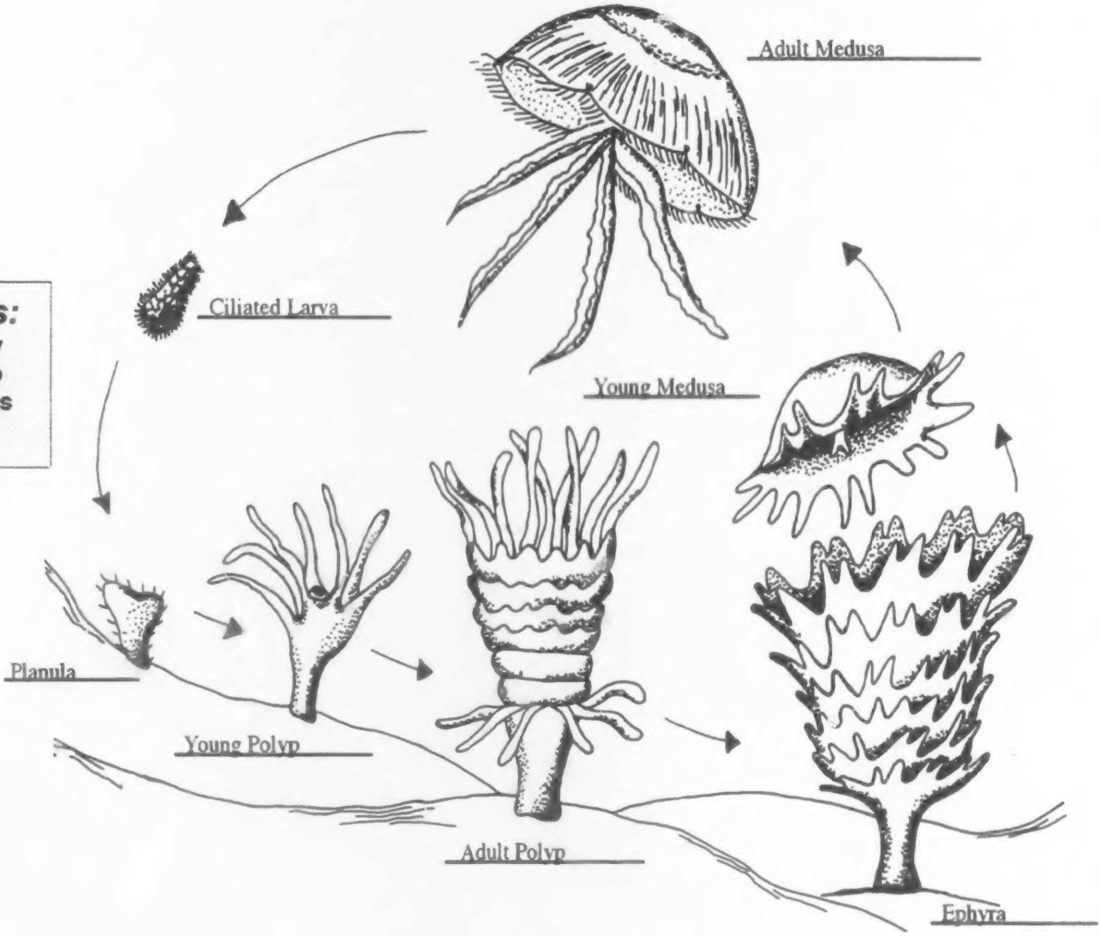
On a separate piece of paper, provide the definition, state the function, and then place the term on the correct line on the diagram:

Base
Tentacle
Bud
Endoderm
Nematocyst
Ectoderm
Mouth

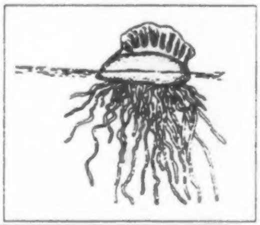


Growing Up Is Tough!

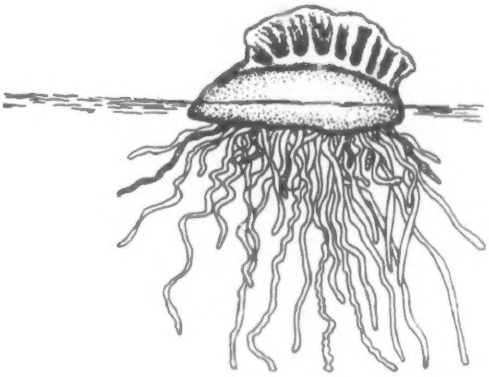
If you think growing up is tough, look at what cnidarians have to go through. Study the life cycle stages of this cnidarian, called an *Auerelia*. Color each organism, and then label the stage (Adult Medusa, Adult Polyp, Ciliated Larva, Young Medusa, Young Polyp, Ephyra, Planula).



Fun Facts:
Jellyfish may consist of up to as much as 95% water!

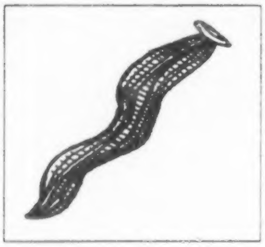


What is a Cnidarian?

Characteristic	Cnidarian Characteristics
Symmetry	Radial.
Segmentation	Absent.
Nervous System	Nerve net.
Reproduction	The medusa reproduces sexually. The polyp reproduces asexually. Different forms often alternate in reproduction.
Digestive System	Digestion occurs in the gastrovascular cavity which has a single opening.
Circulatory System	Occurs via diffusion through body wall.
Muscular and Skeletal System	Have muscle fibers, but not complex.
Body Shape (sketch)	

94

Data Page: Earthworm



1. Place your earthworm gently on a piece of wet paper towel. Take a few minutes to observe the earthworm move. Describe its movements in the space below:
The earthworm moves like a slinky - first one end moves, and then the rest follows.

2. Describe the symmetry: Bilateral Symmetry.

3. How can you tell the difference between the head (anterior) and tail (posterior) of your worm?

The head is closer to the clitellum. Also, the anus end is more tapered than the mouth end.

4. Count the number of segments and record your answer. Answers will vary.

5. Check with some other people in the classroom and write down the number of segments they counted. Answers will vary around 100.

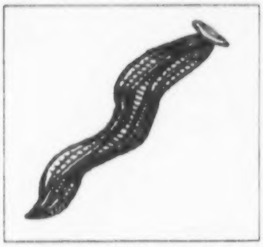
6. Rub your finger gently along the worm and feel the tiny bristles called setae. With a magnifying glass, try to find them. How many do you count on each segment? Four pairs on each segment.

7. What do think is the function of the bristles?
The bristles grasp the soil for burrowing and movement.

8. Look closely to see if you can see blood pumping through the dorsal (back) blood vessel. Describe the pumping. It looks like the faint pumping motion in the vessel of a human wrist.

9. From the head, go about a third down the earthworm. Look for a slight bulge in the body. This is the clitellum where the reproductive organs are located. At what segment is the clitellum located?
The clitellum begins at around segment 30.

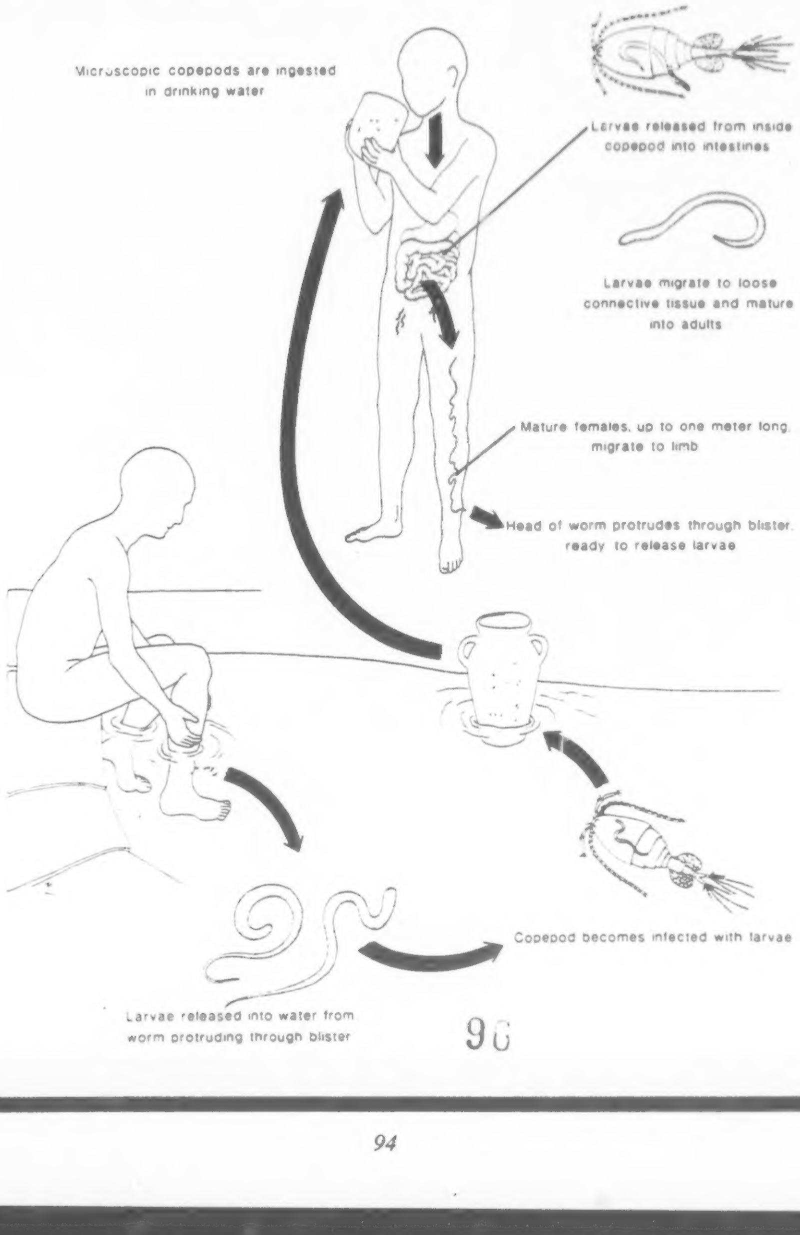
10. Create a diagram of your earthworm below. Label the following features: mouth, anus, segment, setae, and clitellum.



Life Cycle of the Guinea Worm

There are many different types of harmful flatworms. Many of these worms actually live inside the body as a parasites. We call an organism in which a parasite lives a host. Some flatworms live in one or more hosts during their life cycle. One flatworm that has more than one host is the *Guinea worm*.

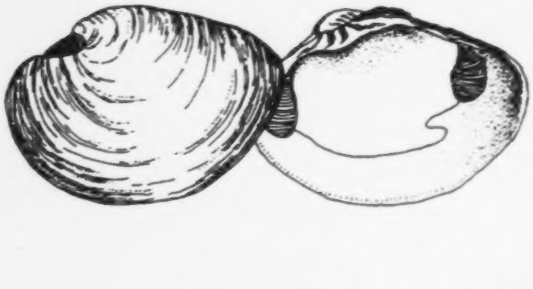
Below are pictures of the different phases in the Guinea worm life cycle. Also included are captions which describe the life cycle. Your task is to cut out the pictures and place them in the correct order with the correct captions. Glue the pictures and captions to a piece of paper. Color the different stages in the life cycle of the worm.

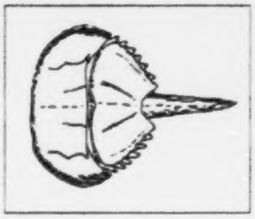

Microscopic copepods are ingested in drinking water
Larvae released from inside copepod into intestines
Larvae migrate to loose connective tissue and mature into adults
Mature females, up to one meter long, migrate to limb
Head of worm protrudes through blister, ready to release larvae
Copepod becomes infected with larvae
Larvae released into water from worm protruding through blister

What is an Annelid?

Characteristic	Annelid Characteristics
Symmetry	Bilateral symmetry.
Segmentation	Segmentation present.
Nervous System	Possess ganglia with a ventral nerve cord and a small brain.
Reproduction	Sexually reproduce. Many species are hermaphroditic.
Digestive System	Have a tube within a tube body plan. Complete digestive system with mouth and anus at opposite ends.
Circulatory System	Circulatory system. Five pairs of aortic arches similar to hearts, pump blood throughout vessels in body.
Muscular and Skeletal System	Circular muscles but no skeleton.
Body Shape (sketch)	

What is a Mollusk?

Characteristic	Mollusk Characteristics
Symmetry	Bilateral.
Segmentation	Absent in most species.
Nervous System	Nervous system is highly developed, particularily in squid and octopi. Possess brain and extensive nerves.
Reproduction	Sexual with internal fertilization.
Digestive System	Complete digestive system.
Circulatory System	Open system.
Muscular and Skeletal System	Many different kinds of muscles. No skeleton. Possess either internal or external shell.
Body Shape (sketch)	 93



Arthropod Anatomy

Your teacher will provide you with an arthropod such as a crab, crayfish, shrimp, or insect. No matter what type of arthropod your teacher gives you, they all have many things in common. Before answering the questions, take a few minutes to look over your creature. Use a magnifying glass to look at some of its parts.

(Crayfish used as example.)

1. What type of arthropod do you have?

Crayfish

2. Is it crustacean, arachnid, or insect? Crustacean

3. Give your reasons for classifying it in this group. Answers will vary.

4. Feel its body and describe it. Possesses a hard outer shell

5. How many appendages does your arthropod have? Two claws, 8 legs, and 2 antennae

6. Describe what the appendages are and what they are used for. Eyes are used for seeing the environment, antennae are used for sensing vibrations.

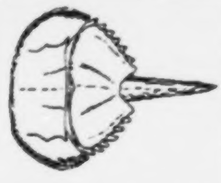
7. How many segments does it have? 3 **Describe their appearance and function.** Head contains brain and sensory organs; thorax contains vital organs; abdomen helps in swimming.

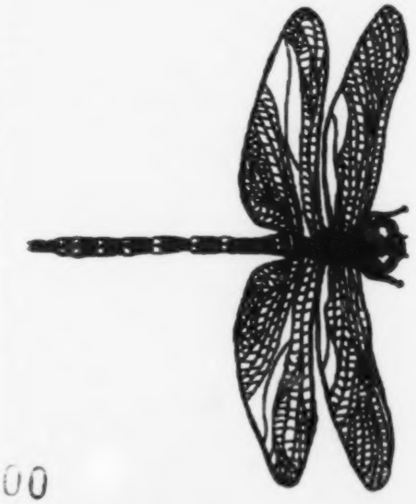
8. Describe how the top and bottom of the animal look differently, and state how these differences help the animal. The top tends to be slightly darker than the bottom of animal. This is quite common in many aquatic animals, helping them to be camoflauged against the bottom and to blend in with the lighter surface above when seen from the bottom.

9. Take a close look at the head. List all the sensory organs it possesses. antennae and eyes

10. On the back of this page, make a detailed diagram of your arthropod. Label the head, thorax, abdomen, eyes, antenna, mouth, appendages, anus, and any other structures you can identify.

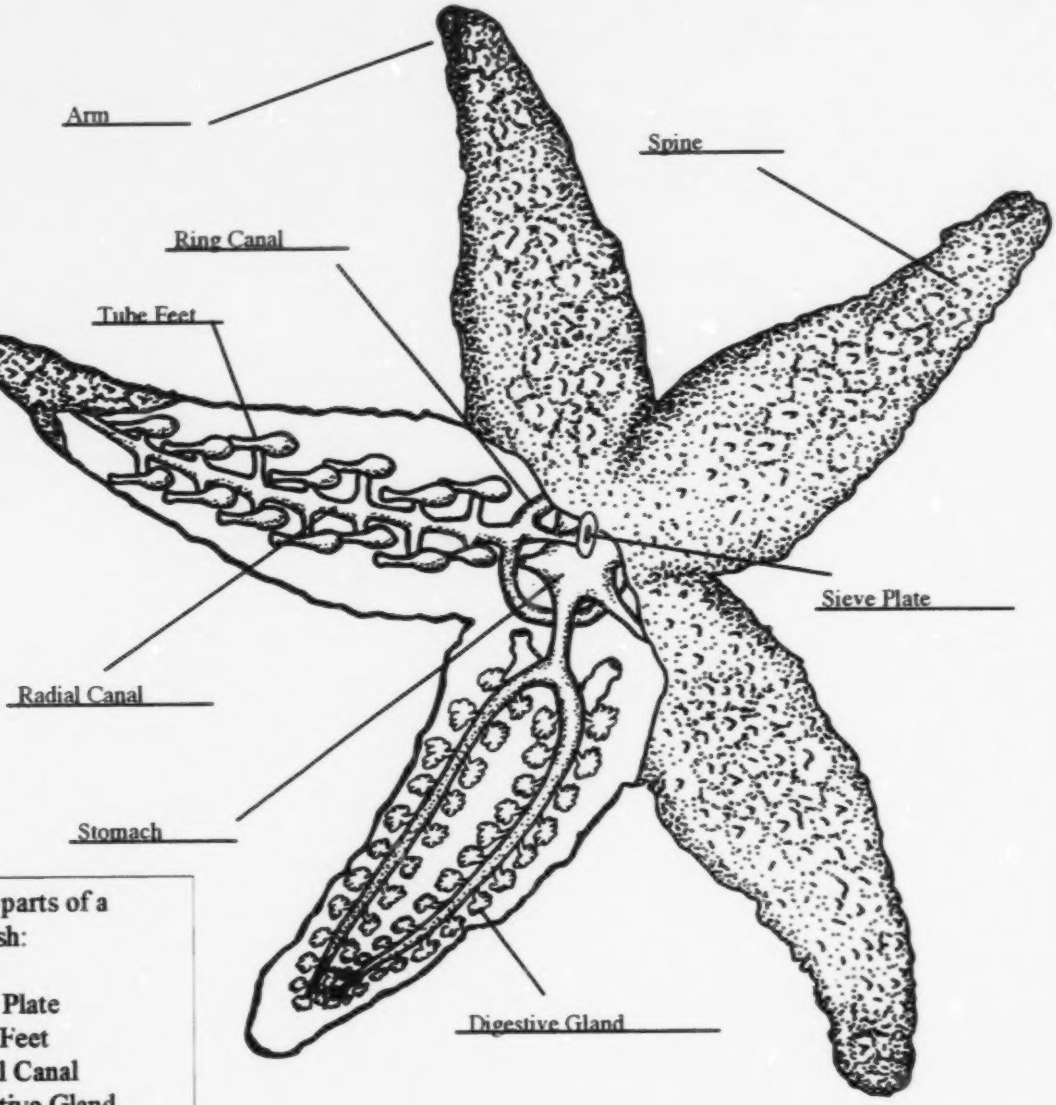
What is an Arthropod?



Characteristic	Arthropod Characteristics
Symmetry	Bilateral symmetry.
Segmentation	Varies - 2 or 3 segments.
Nervous System	Ganglia with vertical nerve cord and a brain.
Reproduction	Sexual reproduction with internal fertilization. Also regeneration.
Digestive System	Complete with two openings.
Circulatory System	Have a heart.
Muscular and Skeletal System	Many different types of muscles. Exoskeleton made of chilton.
Body Shape (sketch)	

Inside Out

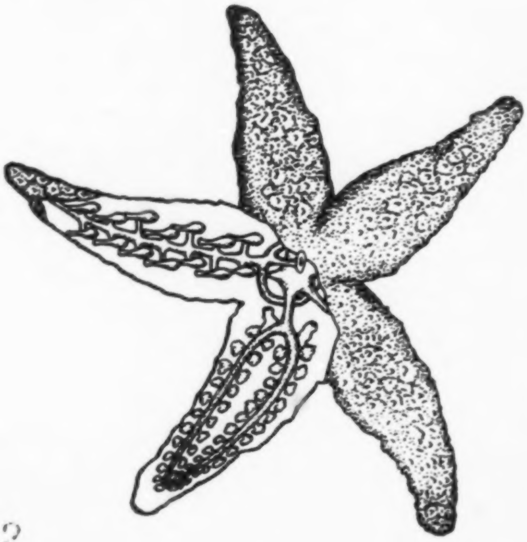
Match the labels to the correct part of the starfish. After correctly matching the term to the body part, define the terms and state the function of the structure on the back of the paper.



Body parts of a Starfish:

- Sieve Plate
- Tube Feet
- Radial Canal
- Digestive Gland
- Stomach
- Arm
- Ring Canal
- Spine

What is an Echinoderm?

Characteristic	Echinoderm Characteristics
Symmetry	Radial.
Segmentation	Absent.
Nervous System	Nerve ring with radial nerves.
Reproduction	Sexual reproduction with external fertilization. Also by regeneration.
Digestive System	Has stomach with mouth and anus. Some species possess stomach or digestive organs which can be inverted.
Circulatory System	Poorly developed with heart absent.
Muscular and Skeletal System	Many muscles that are differentiated. Has endoskeleton made of spiny plates.
Body Shape (sketch)	

Answers to Animals Without Backbones: The Invertebrate Story
Video Quiz for Part 1

1.) **False.** No invertebrates have backbones. Animals with backbones are called "vertebrates."

2.) **True.** Sponges are the simplest multi-cellular animals.

3.) **True.** Cnidarians use the same opening to feed and to eliminate wastes from their bodies.

4.) **Roundworms**

5.) **Bivalves**

Answers to Animals Without Backbones: The Invertebrate Story
Video Quiz for Part 2

1.) **True.** Many echinoderms can regenerate lost body parts.

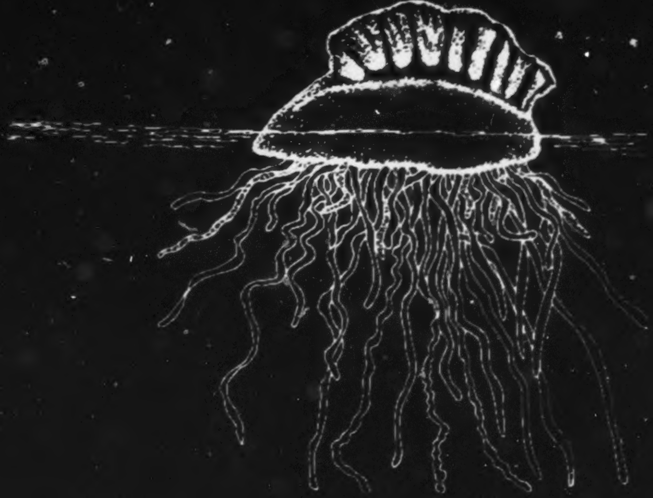
2.) **False.** Echinoderms move about by pumping water in and out of their tube feet.

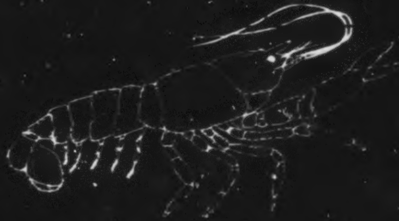
3.) **False.** There are more different kinds or arthropods than there are of any other kind of animal.

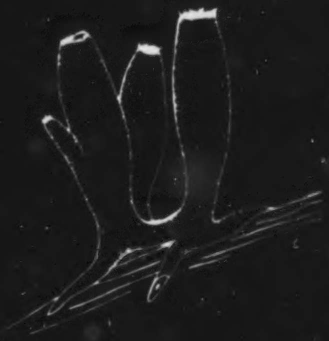
4.) **Exoskeleton**

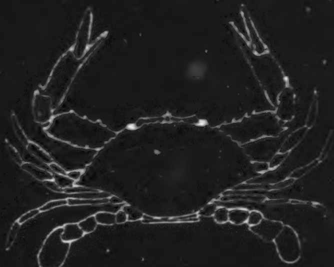
5.) **Legs**

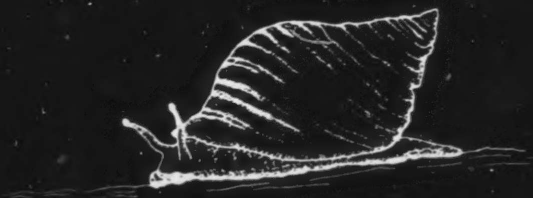
NOTES

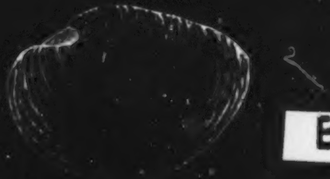












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